



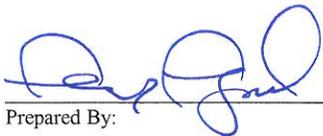
TURBIDITY MONITORING AT SELECT MDOT CONSTRUCTION SITES

STATE STUDY 225

JUNE 2012

**Prepared for:
Mississippi Department of Transportation**

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EXECUTIVE SUMMARY

The objective of this project was to establish baseline turbidity conditions at select construction sites by establishing a water quality monitoring program and documenting MDOT approved BMPs on site. In 2009 the United States Environmental Protection Agency (EPA) proposed a numeric turbidity limit for stormwater runoff at construction sites. The proposed limit of 280 NTUs was stayed due to a miscalculation, and EPA has not released a new numeric limit for turbidity. Current Mississippi Department of Environmental (MDEQ) Water Quality Standards (WQS) require that turbidity 750 feet downstream from the point of discharge not exceed the background turbidity levels upstream of the discharge point by 50 NTU. MDOT has no method of evaluation in place to measure turbidity at construction sites; and therefore, no background data are available to indicate how current erosion and sedimentation BMPs are performing with respect to potential increases in turbidity. Methods of analysis used in this report included the collection of turbidity data from seven sites where MDOT construction posed a potential threat to waters of the state. Prospective sites had to meet certain criteria in order to be used for the study.

Data collection was primarily conducted using remote continuously sampling water quality monitors. Using the MDEQ WQS as a guideline sampling points at each site were situated upstream, in the mixing zone (and/or near the location of discharge) and 750 feet downstream from the discharge point. After a rain event, the site was visited and data were retrieved from the equipment using a laptop computer. A review of the data was performed and, if sufficient data were collected, the equipment was retrieved from the site and then deployed to another location. Equipment malfunctions prevented the collection of useful data from one of the seven sites monitored. Data from the remaining six sites along with information from monthly Thompson Engineering Stormwater Inspections Reports were used to evaluate the turbidity data generated during the study. Data analysis indicated that turbidity levels varied from site to site during a rain event. While some study sites remained below 50 NTUs throughout a rainfall event, others experienced turbidity levels in excess of 3000 NTUs. In general, the findings in this report indicate that, when installed and maintained properly, current E&S BMPs can be effective in controlling turbidity levels with respect to MDEQ's WQS. The report also indicates that further research may be needed to evaluate the most cost effective method by which to collect turbidity data from individual sites.

1.0 INTRODUCTION AND PROBLEM STATEMENT

In December 2009 The United States Environmental Protection Agency (EPA) issued a rule (40 CFR Part 450, Effluent Limitations Guidelines and Standards for the Construction and Development Point Source Category) that established the first national effluent (discharge) limit for stormwater runoff from construction sites. This ruling established the numeric turbidity limit of 280 NTU for stormwater leaving construction sites that disturb 20 or more acres. The numeric limit has since been stayed due to a miscalculation in determining the final limit and is being reevaluated for future release. The outcome of this ruling is of special significance to MDOT because of potential costs required to achieve compliance.

Additionally, current MDEQ WQS require that turbidity 750 feet downstream from the point of discharge not exceed the background turbidity levels upstream of the discharge point by 50 NTU ¹.

Under the current general permits, Best Management Practices (BMPs) are required to be established on sites to prevent sediment from entering waters of the state; however, no monitoring requirements or numeric discharge effluent limits are established. MDOT therefore does not have any data to evaluate how currently utilized, and approved BMPs are performing with respect to potential numeric turbidity limits or current MDEQ WQSs.

The objective of this project was to establish baseline turbidity conditions at select construction sites by establishing a water quality monitoring program and documenting MDOT approved BMPs on site. Collecting turbidity data on existing projects provides information on baseline conditions with respect to the potential new rule, which will likely have a significant impact on MDOT's Stormwater Management Program. Once implemented, the new rule would increase the cost of construction, in addition to the added cost of revising Erosion Control Plans and Storm Water Management Plans. This baseline information is needed to assess the potential impact on MDOT construction projects. In addition, this project provides real world information on the performance of approved BMPs. Furthermore, this effort demonstrates MDOT's continuing efforts to be proactive with respect to environmental issues and regulations.

2.0 RESEARCH PLAN

A Sampling and Analysis Plan (SAP) was prepared and discussed with MDOT in October 2010. Field work was performed using the SAP as a guideline. The SAP included discussions regarding project objectives, sample protocol, sampling equipment, health and safety, and data analysis and reporting. Deviations from the SAP are discussed in the following sections.

2.1 Site Selection

Prospective sites had to meet certain criteria in order to be used for the study. Sites had to be easily accessible in order to get materials and equipment in and out. The depth of water was also a factor in selecting a suitable site. Deep streams were eliminated due to the difficulty in safely installing equipment. Streams that were determined to be so shallow as to keep instruments from being effectively submerged were also eliminated. The volume of water flowing through the site was also evaluated before a site was chosen. High volume flows were eliminated due to the safety issues involved in deploying equipment. Additionally, ephemeral and intermittent streams would not provide sufficient data for the study and were, therefore, eliminated from the study. The phase of site construction was also determining factor in site selection. Seven sites throughout the state were chosen using these guidelines. The site locations can be seen in **Figures A1-G1**.

2.2 Sampling Locations

Using current MDEQ WQS, sampling points at each site were situated upstream, in the mixing zone (and/or near the location of discharge) and 750 feet downstream from the discharge point. Sampling these locations was determined the most effective way to assess how MDOT construction practices are performing in relationship to the proposed numeric limit and the current MDEQ WQS.

2.3 Sampling Equipment

In order to collect sufficient amounts of data, several sampling methods were used. The majority of data were collected using continuously monitoring samplers (InSitu, Inc. Troll 9500 Water Quality Instrument). In addition to the automated samplers, grab samples were taken at each site and turbidity was measured using a portable turbidimeter.

Siphon samplers were constructed of 2-inch PVC and ¼-inch copper tubing. Siphon samplers were situated near the water's edge in the channel in order to collect water as the stream rises within its banks. The sample would then be analyzed using the Hach 2100P Turbidimeter. Siphon samplers were deployed at the first two test sites, but proved difficult to ineffective so their use was discontinued.

The Insitu Inc. Troll 9500 (Troll) water quality monitor was chosen for this study. The Troll is a multi-parameter continuously sampling water quality monitor. The troll measures turbidity in Formazin Nephelometric Units (FNU) using an infrared LED. Three Trolls were deployed at each site, and as previously discussed, were deployed in upstream, mixing zone and downstream locations. The Troll's measuring capabilities include but are not limited to turbidity, water temperature and barometric pressure. For

purposes of this study only turbidity measurements were evaluated. The Troll was programmed to sample for turbidity every five minutes while deployed. Each Troll was synchronized to sample at or near the same time in order to accurately correlate data. Trolls were also synchronized with a rain gauge data logger.

Initially the Trolls were deployed using a float that would allow the monitor to rise and fall with water levels. This method proved ineffective at streams with low water levels because the sensors would become clogged with debris and silt. Ultimately, metal fence posts were driven into the channel and the troll was secured using metal hose clamps. The troll was positioned on the post at a height that would keep the sensors below the water level for the entire monitoring period. This unit is completely submersible, so little concern was given to the prospect of the water level rising too high.

Rainfall was also monitored at each site using a tipping bucket rain gauge and data logger. The RainWise tipping bucket and RainLog data logger manufactured by RainWise Inc. were chosen for this task. The tipping bucket gauge was mounted on a 4x4 wooden post with the data logger attached in the water tight compartment inside the bucket. For purposes of this study a rainfall event is characterized by 0.1 inches of rain within a 24 hour period.

In addition to the on-site rain gauge, Rainwave precipitation monitoring service was used for some sites. This service was based of Auburn, Alabama. Rainwave uses Doppler weather technology correlated with existing USGS gauging stations in the area to give a precise measurement of rainfall at a given latitude and longitude. The data is reported in monthly e-mails. Rainwave also sends alerts when a rainfall threshold is exceeded at a given site.

Specification sheets for all equipment used can be found in **Appendix H**.

2.4 Data Retrieval

After a rainfall event, the site was visited and data were retrieved from the equipment using a laptop computer. A review of the data was performed and , if sufficient data were collected, the equipment was retrieved from the site. If no rainfall event occurred, the site was visited to replace batteries in all equipment after two to three weeks.

Data from the Troll were downloaded from the device using Win-Situ 4 Instrument Control Software. Data were retrieved in five-minute intervals for the duration of the monitoring period.

Data from the RainWise rain gauge were extracted using RL-Loader 2.2. Data could be extracted by daily rainfall amount, five-minute interval or by rainfall event.

3.0 INDIVIDUAL SITE DESCRIPTIONS

This Section provides descriptions of the site and the stage of construction during a sampling event. The site photos are representative of conditions present during the sampling event.

3.1 Tallashua Creek- SR 19 Collinsville, Mississippi

The initial study site was located in Neshoba County near Collinsville, Mississippi. The MDOT construction project consisted of constructing a four line highway to replace the existing two-lane highway between the Lauderdale County line and State Route 492 in Neshoba County. Turbidity monitoring at the site was conducted between February 2, 2011 and February 9, 2011. The area of interest for this study was the bridge replacement over the Tallashua Creek, approximately 2.7 miles north of the Neshoba-Newton County line. The old bridge was demolished and a new bridge was constructed parallel to the two newly constructed traffic lanes. When construction of the new bridge was complete, traffic was diverted across the new bridge while the old bridge was replaced. The approximate disturbed area for the bridge replacement was 6.3 acres.

Erosion and sedimentation control BMPs on the site included silt fence around the perimeter of the site, rip rap stabilized slopes on the stream channel and erosion control mats on some of the slopes.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site. In addition, siphon samplers were deployed at the discharge point in the rip-rap lined ditches extending from the roadbed to the receiving stream.

A map of the location can be seen in **Figure A-1**. An aerial photograph of the site can be seen in **Figure A-2**. Photographs of the site and BMPs in place can be seen in **Appendix A, Photos A-1 through A-9**.

3.2 Riverdale Creek-US 51 Grenada, Mississippi

The second data collection site in the study was located in Grenada, Mississippi north of the Yalobusha River. Improvements to US 51 at the site included the construction of four-lane highway to replace the existing two-lane highway. Turbidity monitoring at the site was conducted between May 4, 2011 and May 16, 2011. The area of interest for this study is the bridge replacement at Riverdale Creek. A detour bridge was constructed parallel to the existing bridge. When construction of the new bridge was complete, traffic was diverted across the new bridge while the old bridge was replaced. The approximate disturbed area for the bridge replacement was 4.57 acres.

Erosion and sedimentation control BMPs on the site were minimal. The site did have a silt fence around the perimeter, but it was damaged and/or held sediment in several places. Slopes on the site were left unprotected with very little to no vegetation in place. Ditches throughout the site were unlined with no wattles or rock check dams in place.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site. In addition, siphon samplers were deployed in the rip rap lined ditches running from the roadbed to the receiving stream.

A map of the location can be seen in **Figure B-1**. An aerial photograph of the site can be seen in **Figure B-2**. Photographs of the site and BMPs in place can be seen in **Photos B-1** through **B-11**.

3.3 Tangipahoa River-US 51 Magnolia, Mississippi

The third data collection site in the study was located in Magnolia, Mississippi where Mississippi Highway 51 crosses the Tangipahoa River. Improvements to US 51 at the site included the construction of four-lane highway to replace the existing two-lane highway. Turbidity monitoring at the site was conducted between May 25, 2011 and June 2, 2011. The area of interest for this study was the bridge replacement at the Tangipahoa River. A detour bridge was constructed parallel to the existing bridge. When construction of the new bridge was complete, traffic was diverted across the new bridge while the old bridge was replaced. The approximate disturbed area for the bridge replacement was 4.5 acres.

Erosion and sedimentation control BMPs on the site included the following: silt fence around the perimeter of the disturbed areas, slopes line with rip rap or vegetation, silt fence along the river bank and wattles in ditches leading into the river.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site.

A map of the location can be seen in **Figure C-1**. An aerial photograph of the site can be seen in **Figure C-2**. Photographs of the site and BMPs in place can be seen in **Appendix C, Photos C-1** through **C-6**.

3.4 Terrapin Skin Creek- SR 468 Pearl, Mississippi

The fourth data collection site in the study was located in Pearl, Mississippi approximately 0.5 miles south of the intersection of Mississippi Highway 468 and Greenfield Road. Improvements to SR 468 at the site included the construction of a new bridge. Turbidity monitoring at the site was conducted between August 9, 2011 and August 21, 2011. The area of interest for this study was the bridge replacement at

Terrapin Skin Creek. A detour bridge was constructed parallel to the existing bridge. When construction of the new bridge was complete, traffic was diverted across the new bridge while the old bridge was replaced. The approximate disturbed area for the bridge replacement was 6 acres.

Erosion and sedimentation control BMPs on the site included the following: silt fence around the perimeter of the disturbed areas, storm water outlets protected with silt fence, rip-rap, and a rip-rap lined sediment basin near the stream channel.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site.

A map of the location can be seen in **Figure D-1**. An aerial photograph of the site can be seen in **Figure D-2**. Photographs of the site and BMPs in place can be seen in **Appendix D, Photos D-1 through D-5**.

3.5 Yockanookany River- SR 16 Leake County, Mississippi

The fifth data collection site in the study was located near Carthage, Mississippi approximately 2.5 miles west of the intersection of SR 16 468 and SR 25 in Leake County . Improvements to SR 16 at the site included the construction of four-lane highway to replace the existing two-lane highway. Turbidity monitoring at the site was conducted between October 13, 2011 and November 22, 2011. The area of interest for this study was the bridge replacement at the Yockanookany River. During the monitoring period bridge construction had not begun, but the road beds for the new highway lanes had been constructed. Approximate disturbed acreage at the site is 5.54 acres.

Erosion and sedimentation control BMPs on the site included the following: silt fence around the perimeter of the disturbed areas, all channels and ditches leading to the river had wattles or rock check dams installed, and most slopes were stabilized with vegetation and mulch.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site.

A map of the location can be seen in **Figure E-1**. An aerial photograph of the site can be seen in **Figure E-2**. Photographs of the site and BMPs in place can be seen in **Appendix E, Photos E-1 through E-7**.

3.6 SR 15 New Albany, Mississippi

The sixth data collection site in the study was located near New Albany, Mississippi approximately 0.15 miles south of the Union- Tippah County line. Improvements to SR

15 at the site included the construction of a new box culvert. The area of interest for this study was the box culvert construction at an unnamed tributary to Jasper Creek. Turbidity monitoring at the site was conducted for a twelve day period between January 25, 2012 and February 7, 2012. The approximate disturbed area for the bridge replacement was 6 acres.

Erosion and sedimentation control BMPs on the site included silt fence around the perimeter of the disturbed areas. The silt fence, however, was damaged or not installed properly in some areas. Hay bales were placed in areas of concentrated flow and in the stream near the culvert where stormwater entered the stream channel. Drain inlets were protected with hay bales and silt fence. Within the site there were several exposed slopes with no vegetation or mulch in place.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site.

A map of the location can be seen in **Figure F-1**. An aerial photograph of the site can be seen in **Figure F-2**. Photographs of the site and BMPs in place can be seen in **Appendix F, Photos F-1 through F-10**.

3.7 SR 475 Pearl, Mississippi

The seventh data collection site in the study was located in Pearl, Mississippi, at the intersection of International Drive and US 80. Improvements to SR475 at the site included the construction of a bypass that will divert thru traffic traveling between SR 25 and US 80 away from the Jackson-Evers International Airport entrance. Turbidity monitoring at the site was conducted between February 29, 2012 and March 14, 2012. The approximate disturbed area for the bridge replacement is approximately 50 acres. Stormwater runoff from US 80 enters the site at the intersection of US 80 and International Drive then flows through the site where several channels from the site converge into one single channel and exits at the northern boundary. Approximately 0.1 miles south of the roundabout intersection of International Drive and Old Brandon Road another channel enters the site. This channel was chosen for monitoring because of its consistent flow of water. The water in the channel appeared to be cloudy (indicating increased turbidity) on the day equipment was deployed. A review of aerial photographs indicate that there is an area of new development up-gradient from the site that may be contributing to the turbidity of the stream. It was determined that the results would be consistent with the goal of the study because this channel, however cloudy before it enters the site, would still give a good background measurement of turbidity.

Erosion and sedimentation control BMPs on the site included silt fence around the perimeter of the disturbed areas. Slopes were either mulched or had vegetation in place. Wattles were installed throughout the ditches on the site. A large sediment basin was

constructed near the northern edge of the site. Ditches running parallel to Old Brandon Road had rock check dams installed to capture sediment before exiting the site. The major stormwater conveyance channel was partially lined with rip rap and grouted.

The Trolls were deployed 250 feet upstream of the construction site, in the mixing zone and 750 feet downstream from the site. A map of the location can be seen in **Figure G-1**. An aerial photograph of the site can be seen in **Figure G-2**. Photographs of the site and BMPs in place can be seen in **Appendix G, Photos G-1 through G-8**.

4.0 RESULTS

At the end of each monitoring period, the site data was reviewed and graphical representations were created. Graphs plotted turbidity (FNU) in relationship to rainfall (inches). Time is represented on the x-axis, turbidity on the primary y-axis and rainfall on the secondary y-axis. Use of a secondary y-axis was necessary due to the high delta between the rainfall and turbidity values.

All time will be displayed in 24 hour format, 00:00-23:59.

4.1 Tallashua Creek- SR 19 Collinsville, Mississippi February 2-9, 2011

Due to quality issues with the Troll, only data from the upstream and mixing zone monitors was retrieved. However, data from these two monitors were questionable as well. Differences in turbidity over a distances of only 250 feet were so extreme it was determined that the monitor giving the higher of the measurements, upstream, was defective. The upstream monitor continued to give a turbidity measurement of 2873.4 NTU for a period of one week while the mixing zone monitor gave measurements that steadily decreased overall, only varying by \pm a few tenths for the last week it was deployed. Due to the quality issues with the data, no graphs were created for this site.

4.2 Riverdale Creek- US HWY 51 Grenada, Mississippi May 4-16, 2011

On May 13, 2011 the site in Grenada received 0.65 inches of rain between 0630 and 0834. At 0905 the downstream turbidity (2458 NTU) exceeded the upstream turbidity (414 NTU) by > 50 NTU for the first time. The creek recovered for a ten-minute period between 09:50 and 10:00 then was in compliance with MDEQ WQSs regulatory for sporadic intervals until it fully recovered at 11:45.

Graphic representations of data from this site can be seen in **Appendix B, Charts B-1 through B-4**.

4.3 Tangipahoa River- US HWY 51 Magnolia, Mississippi May 25- June 2, 2011

On May 17, 2011 this site was inspected by Thompson Engineering (Thompson) Stormwater Inspectors and was reported to have no deficiencies related to erosion and sedimentation control BMPs. On May 26, 2011 the site received 0.19 inches of rain between 02:54 and 09:59. The downstream turbidity remained within 50 NTU of the turbidity measured upstream for the duration of the rain event and throughout the monitoring period. In addition, turbidity measurements at this site remained well below the formerly proposed numeric limit of 280 NTU.

Graphic representations of data from this site can be seen in **Appendix C, Chart C-1**.

4.4 Terrapin Skin Creek- SR 468 Pearl, Mississippi August 9- 21, 2011

On July 26, 2011 this site was inspected by Thompson Stormwater Inspectors and reported to have two minor deficiencies related to erosion and sedimentation control BMPs. In the area surrounding the detour bridge minor rills and washes were noted above the rip-rap lined embankment. Additional rip-rap was recommended above the existing rip-rap in order to prevent sediment from entering the stream. A section of silt fence was observed to have been damaged during recent construction activities. Maintenance was recommended for this, as well. According to the 0.1 inches of rainfall over a 24 hour period standard, this site did not encounter a rain event. There were, however, significantly high(>3000 NTU) turbidity measurements at the mixing zone monitor beginning around 14:40 on August 18, 2011. A Thompson Stormwater Inspection Report dated August 22, 2011 does not indicate that MDEQ was contacted for any erosion events that may have led to elevated turbidity measurements.

Graphic representations of data from this site can be seen in **Appendix D, Charts D-1 through D-3**.

4.5 Yockanookany River- SR 16 Leake County, Mississippi Oct. 13-Nov. 22, 2011

This site has consistently had no deficiencies related to erosion and sedimentation control BMPs since the initial inspection performed by Thompson Stormwater Inspectors on August 30, 2011. Throughout the entire monitoring period, this site stayed within the MDEQ 50 NTU regulation. On October 28, 2011 the site received 0.17 inches of rain. On November 3, 2011 the site received 0.31 inches of rain. On November 16, 2011 the site received 0.47 inches of rain. Throughout the monitoring period this site remained below the formerly EPA proposed numeric turbidity limit of 280 NTU.

Graphic representations of data from this site can be seen in **Appendix E, Charts E-1 through E-4**.

4.6 SR 15 New Albany, Mississippi January 25- February 7, 2012

The first recorded rainfall was recorded at 22:00 on January 25, 2012. Between 03:00 and 07:00 on January 26, the site received approximately 0.14 inches of rain. After this period the turbidity reading at the mixing zone is seen to rise, but remain within regulatory limit. The first recorded exceedance of the 50 NTU WQS was seen at 12:20 on January 26, 2012. At this point the total rainfall equaled 0.45 inches with an instantaneous peak of .08 inches at 23:55 PM. A likely explanation is that rainfall until this point did not exceed the grounds capability to absorb or hold water.. The site received approximately 0.14 inches of rain in the five-hour period before the WQS was exceeded. The highest spike in turbidity (>2600 NTU) was observed around 16:40 on January 26. This spike in turbidity coincided with the instantaneous peak in rainfall of 0.14 inches. After the last recorded rainfall at 09:30 on January 26, the stream remained out of compliance with MDEQ standards until 11:40 on the same day.

A second rainfall event was observed on February 4, 2012 February 4. The 50 NTU regulation was exceeded after 0.44 inches of rainfall in an 18.5 hour period. As was seen in the previous rain event, the increase in turbidity mimics the increase in rainfall. The downstream and mixing zone turbidity readings spike into the thousands while the upstream reading remains below 500 NTU. At the point where the downstream turbidity falls to within 50 NTU of upstream, total rainfall onsite was 0.71 inches.

Graphic representations of data from this site can be seen in **Appendix F, Charts F-1 and F-2.**

4.7 SR 475 Pearl, Mississippi February 29- March 14, 2012

On February 12, 2012 this site was inspected by Thompson Stormwater Inspectors. The following erosion and sedimentation control deficiencies were noted in the report: the median ditch located between SR 475 and the newly constructed tie-in ramps were overwhelmed by sediment run-off; BMPs installed in the ditch line adjacent to Old Brandon Road were overwhelmed from stormwater run-off causing sediment to be discharged offsite (MDEQ notified); minor sediment was observed leaving the site on the outflow end of the 60-inch pipe; rills and washes have begun to form on the slopes that were previously seeded with permanent grass causing sediment to be deposited in the ditch line and sediment runoff had overwhelmed the BMPs installed around the 36-inch Jack and Bore pipe inlet.

On March 2, 2012 the site received 0.59 inches of rain. The first recorded rainfall was 20:54 on March 2 and the rain event lasted until 03:39 on March 3. During sampling only the mixing zone and downstream monitors were functioning properly. At 22:20 on March 2 the mixing zone monitored recorded turbidity as being 305 FNU then reaching 2784 FNU at 22:35. At 23:55 the turbidity was recorded at 277 FNU. The total rainfall

amount at 22:20 was 0.49 inches. The downstream monitor read 620 FNU at 22:45 on March 2 and 2391 FNU by 22:50. At 01:05 turbidity was recorded at 280 FNU.

A second rainfall event was recorded on March 8-10, 2012. This event produced a total of 1.51 inches of rain on the site. At 22:45 the mixing zone monitor reported a turbidity measurement of 2782 FNU. Ten minutes later at the downstream sampling location turbidity was measured at 1166 FNU. Total rainfall onsite at 22:46 was recorded at 0.23 inches. Turbidity measurements continued to be greater than 1000 FNU until 00:10 March 9 at the mixing zone (914 FNU) and 00:20 March 9 downstream (940 FNU). Another 1000+ FNU spike was recorded at both sampling locations at 01:15 March 9 (1008-mixing zone, 1070-downstream). Turbidity remained above 1000 FNU at the mixing zone for 15 minutes; and for 45 minutes, at the downstream location. Total rainfall onsite at 01:15 was recorded at 0.47 inches. The mixing zone recovered to below 280 FNU at 03:10 March 9; downstream recovered at 03:55. Graphic representations of data from this site can be seen in **Appendix G, Charts G-1 and G-2**.

5.0 CONCLUSIONS

The goal of State Study 225 was to establish baseline turbidity conditions at select construction sites by establishing a water quality monitoring program and documenting existing and MDOT approved BMPs. Data collected from the various sites throughout the state were collected up-gradient from the site (background), in the mixing zone, and 750 feet down-gradient from the construction site. Reviews of data collected indicate that many of the sites where the monitoring equipment was deployed exhibited significant turbidity spikes above background levels during storm events. The turbidity increases were in some cases far above the initially proposed EPA numeric limit of 280 NTUs. State Study 225 was successful in establishing baseline stream data utilizing up-gradient, mixing zone, and down-gradient (750 feet downstream) sample locations to assess impacts from adjacent MDOT construction sites, but did not provide data for point source discharge locations prior to discharge to the receiving streams.

Data collected in this study reinforces the importance of the proper installation and maintenance of BMPs on construction sites. Sites with no prior or current deficiencies in erosion and sedimentation control BMPs at the time of monitoring remained within the MDEQ WQS and below the formerly proposed 280 NTU numeric turbidity limit. On the other hand, sites where deficiencies were noted in stormwater inspections had turbidity measurements that were not in compliance with MDEQ WQS or the proposed EPA ruling. Although State Study 225 was limited in scope, findings appear to demonstrate that, if properly installed and maintained, MDOT's current BMPs appear capable of meeting the MDEQ WQS.

Although no direct discharge data were collected, the turbidity data obtained were useful in evaluating the a baseline condition with respect to the potential EPA numeric turbidity

limit, which will likely have a significant impact on MDOT's Stormwater Management Program. In addition, this project has provided information on the performance of approved BMPs. Additionally, the study revealed reliability issues with the monitoring equipment selected to collect the data. Other types of monitoring equipment and deployment methods will be necessary to acquire point source data.

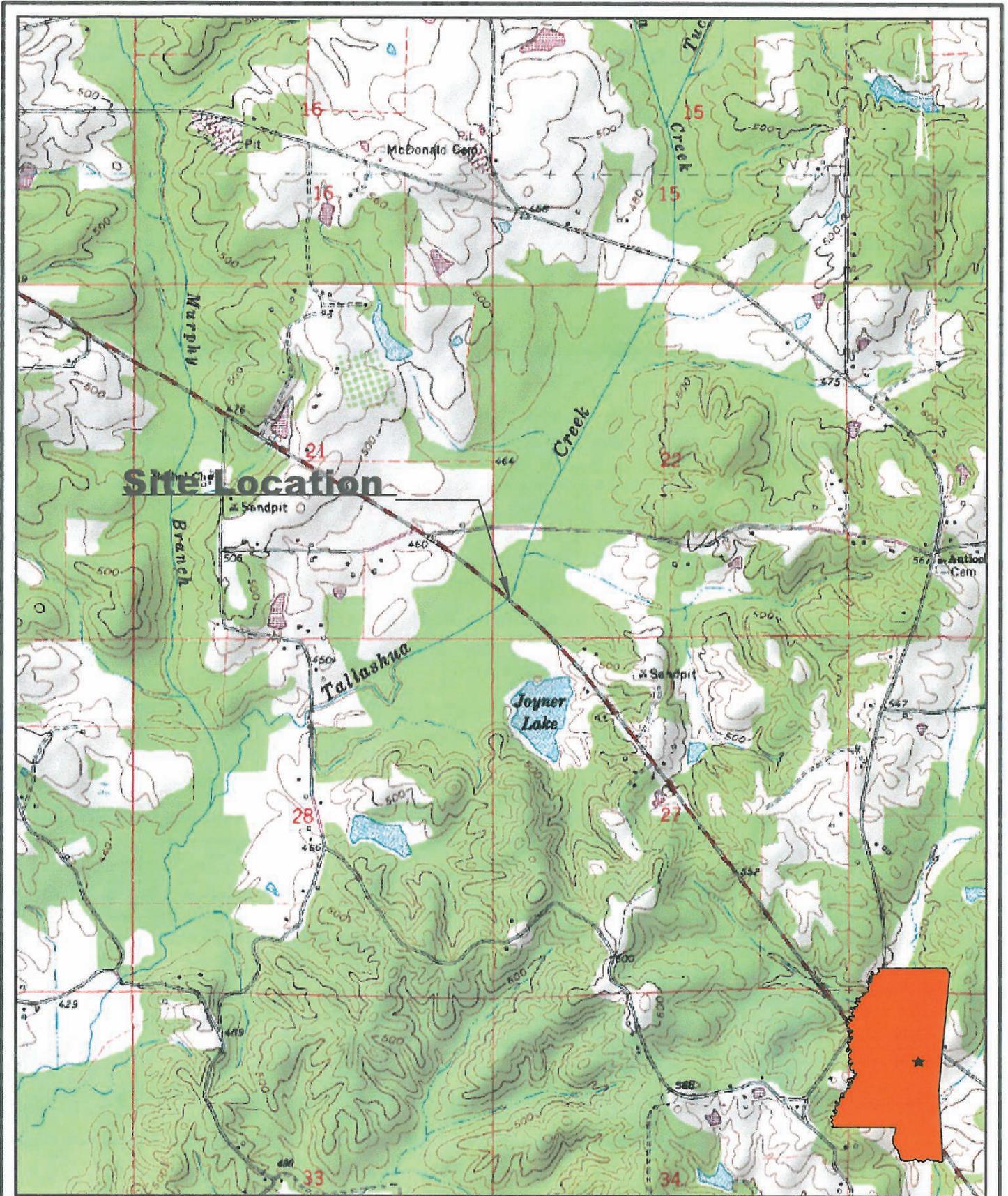
REFERENCES

1. State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters. Adopted by the Mississippi Commission on Environmental Quality August 23, 2007.

APPENDIX A

Figures, Charts, and Photographs

Tallashua Creek – SR 19 Collinsville, Mississippi



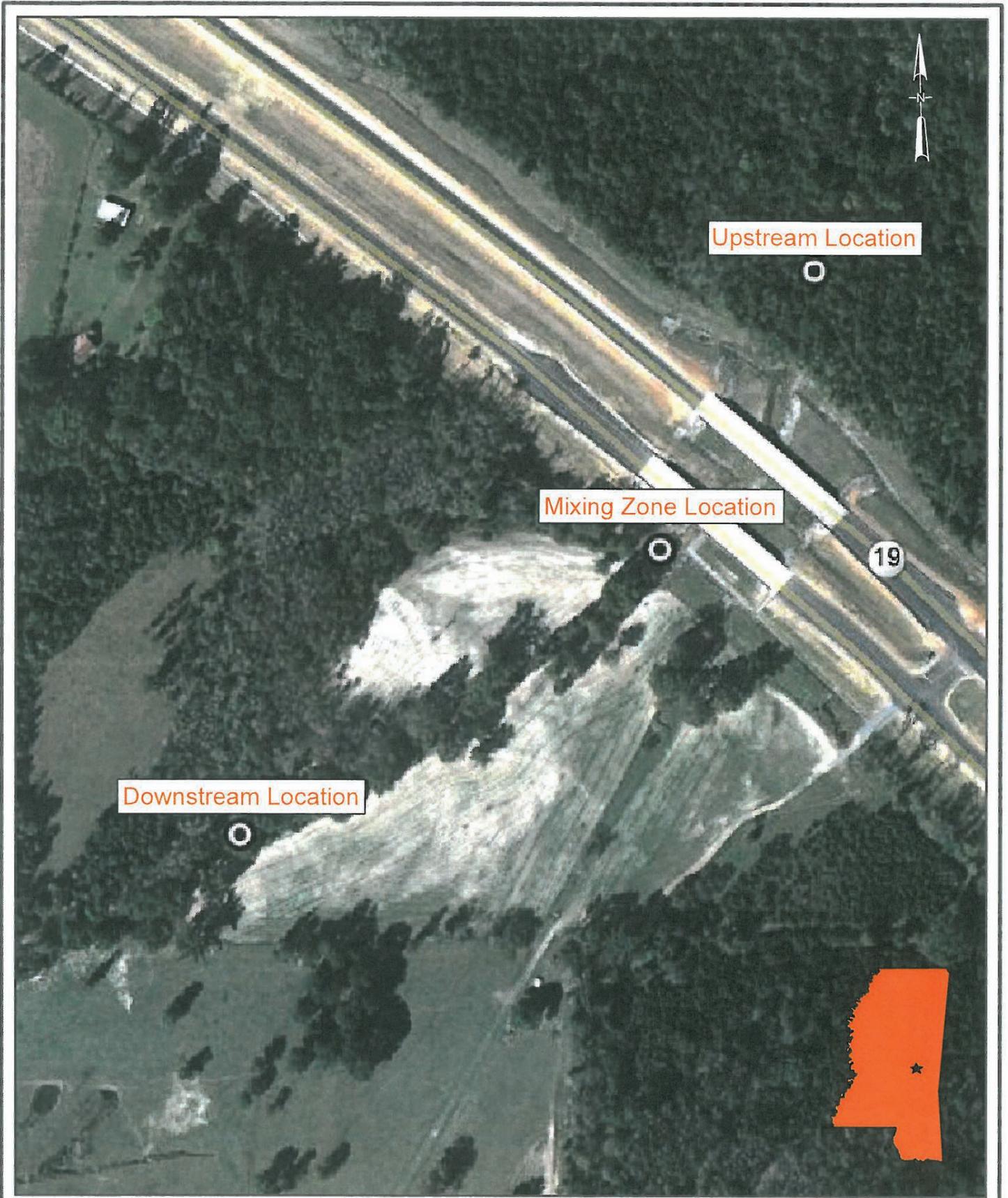
MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure A-1
 Tallashua Creek
 SR 19 Collinsville, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure A-2
 Tallashua Creek
 SR19 Collinsville Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012

TALLASHUA CREEK- SR 19 COLLINSVILLE, MISSISSIPPI



Photo A-1 Installation of the Troll 9500 at the downstream sampling location



Photo A-2 Upstream sampling location Troll in place



Photo A-3 Siphon sampler installation



Photo A-4 Sparse vegetative cover and signs of erosion on the slope



Photo A-5 Large gully forming due to a lack of vegetation or any other BMP



Photo A-6 Silt fence waddles and rip rap in place



Photo A-7 Rip rap lined bank and silt fence around stock pile of dirt



Photo A-8 Rip rap lined embankment with waddles installed at the top

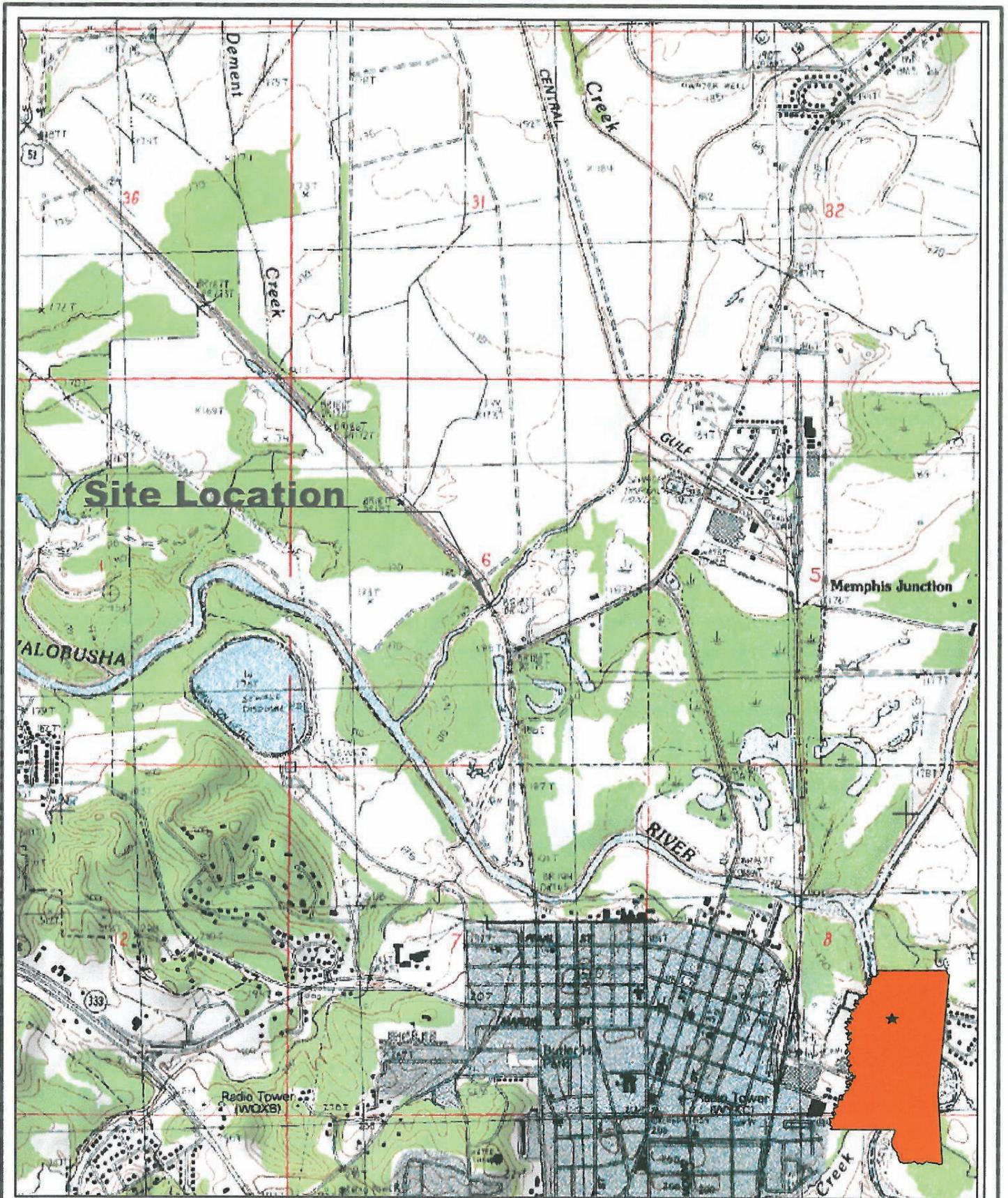


Photo A-9 Evidence of sedimentation at the bottom of unprotected slopes

APPENDIX B

Figures, Charts, and Photographs

Riverdale Creek – US51 Grenada, Mississippi



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure B-1
 Riverdale Creek
 US 51 Grenada, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012



MDOT State Study 225
Turbidity Monitoring at Select MDOT
Construction Sites



Figure B-2
Riverdale Creek
US 51 Grenada, Mississippi

PROJECT NO:
09-2118-0034

DATE:
June 2012

RIVERDALE CREEK- US 51 GRENADA, MISSISSIPPI



Photo B-1 Silt fence installed on the bank of the main stream



Photo B-2 Silt fence in need of maintenance



Photo B-3 No vegetation or BMPs in place on the slope



Photo B-4 No BMPs in place to prevent sediment from entering the stream



Photo B-5 Silt fence installed near an existing ditch that leads to the stream

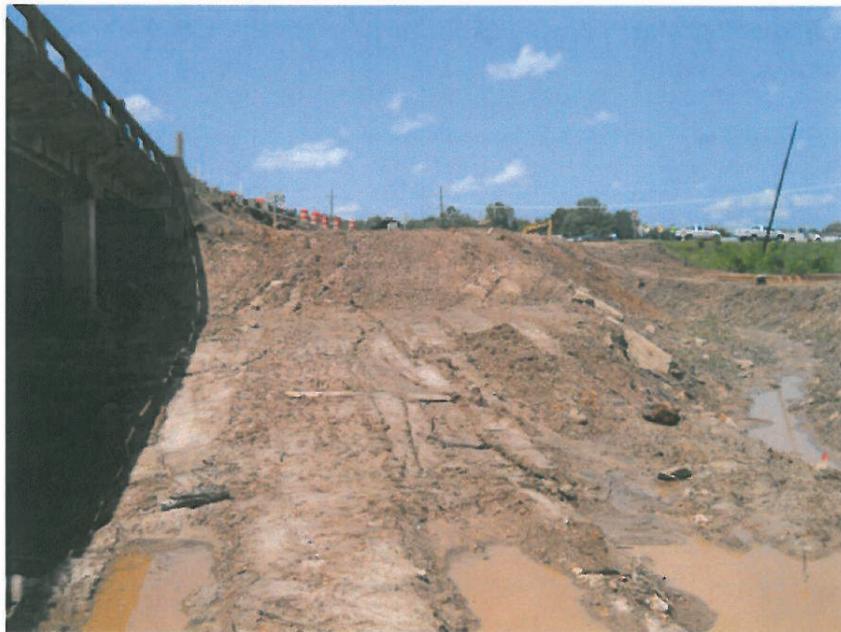


Photo B-6 Unprotected slope with no BMPs in place



Photo B-7 Stream banks with no BMPs installed



Photo B-8 Stream banks with no BMPs installed



Photo B-9 No BMPs installed, no vegetation



Photo B-10 Silt fence in need of maintenance



Photo B-11 Inadequate construction entrance

Chart B-1

Riverdale Creek Hwy 51 Grenada, Mississippi
24 Hour period of Compliance
No Rainfall

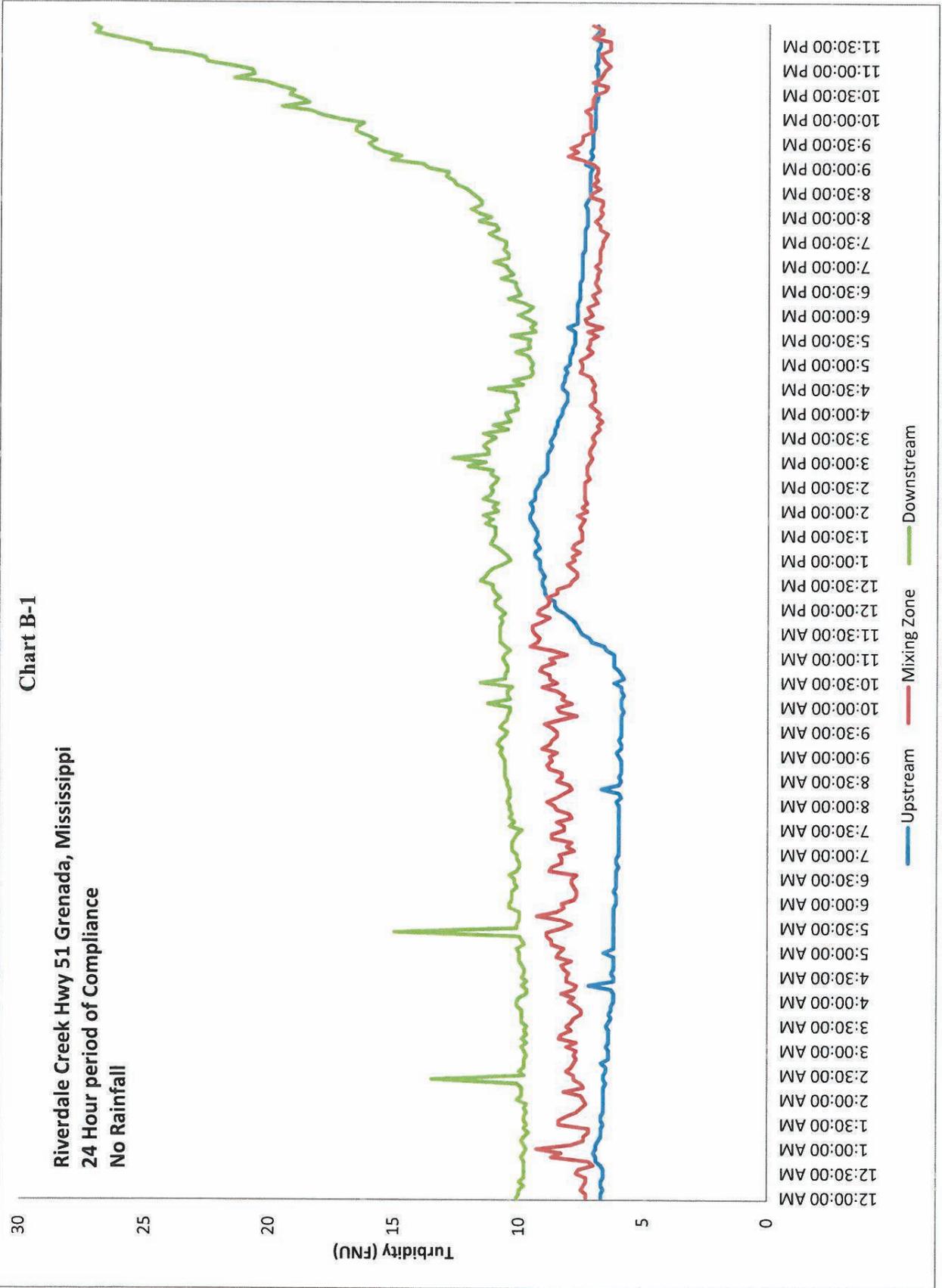
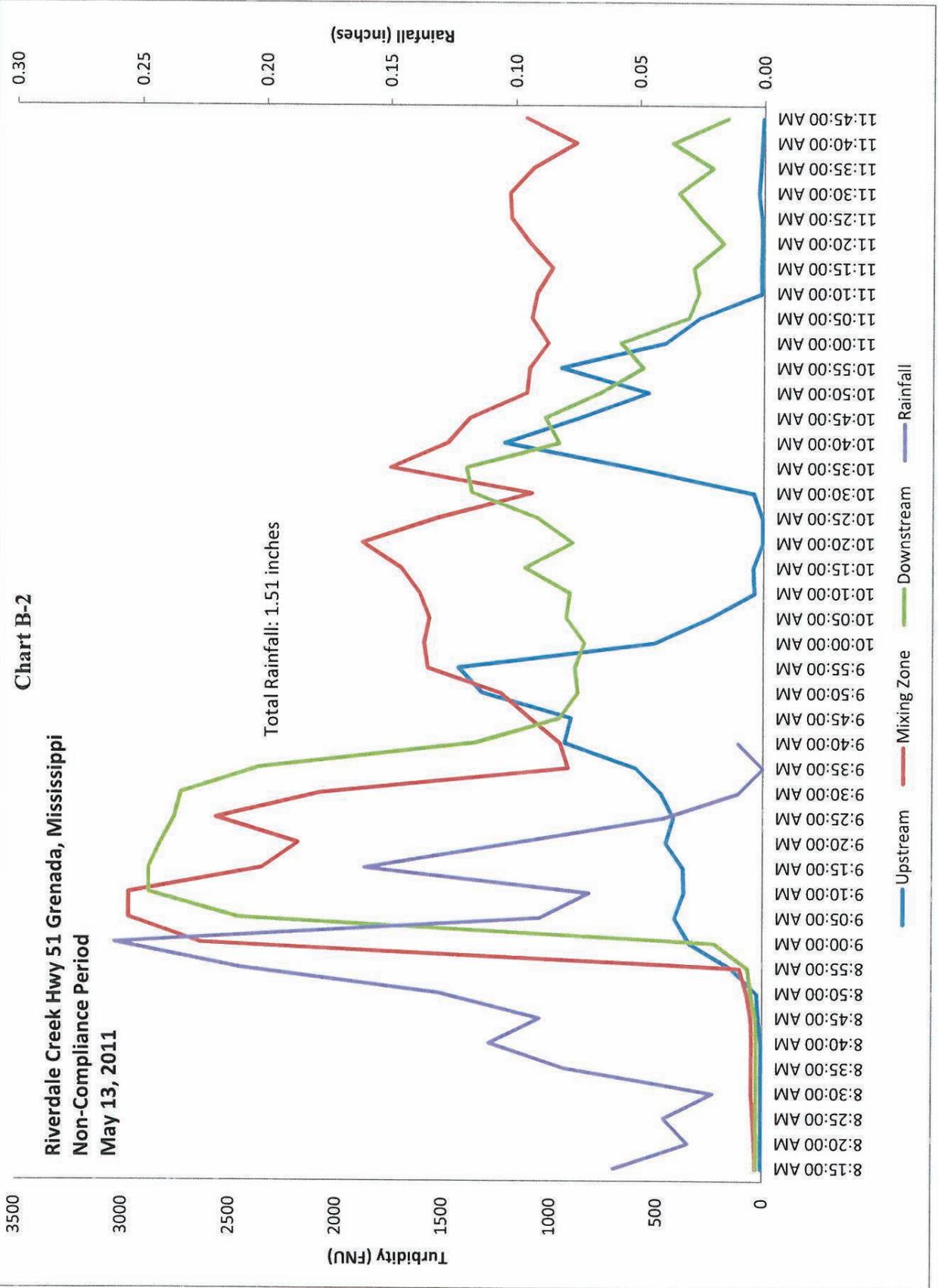


Chart B-2

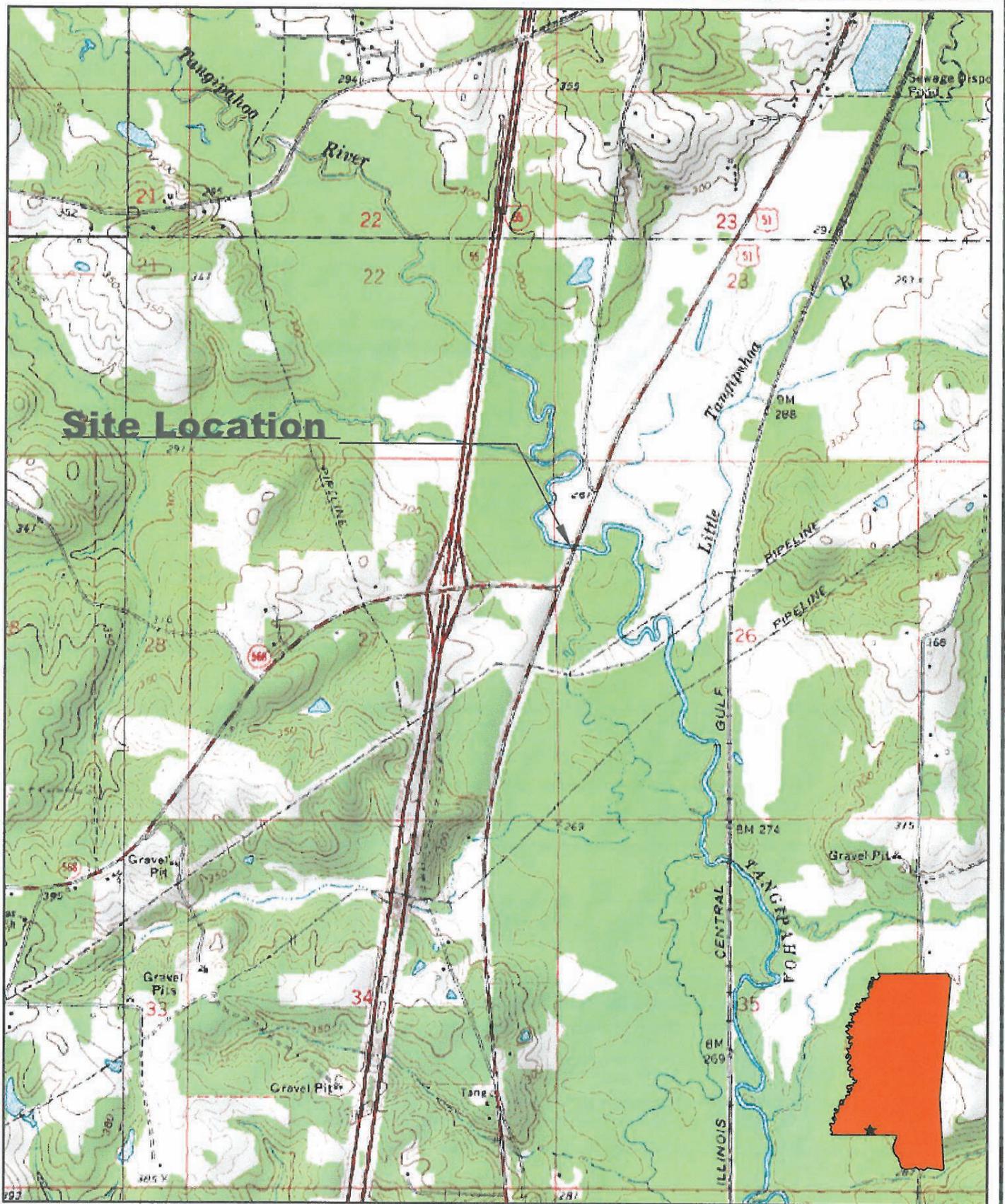
Riverdale Creek Hwy 51 Grenada, Mississippi
Non-Compliance Period
May 13, 2011



APPENDIX C

Figures, Charts, and Photographs

Tangipahoa River, - US 51 Magnolia, Mississippi



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure C-1
 Tangipahoa River
 US 51 Magnolia, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure C-2
 Tangipahoa River
 US51 Magnolia, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012

TANGIPAHOA RIVER-US 51 MAGNOLIA, MISSISSIPPI



Photo C-1 Rock check dam installed, slope seeded and mulched



Photo C-2 Slope seeded and mulched



Photo C-3 Partially grassed, the remainder is seeded and mulched



Photo C-4 Rip rap lined embankment



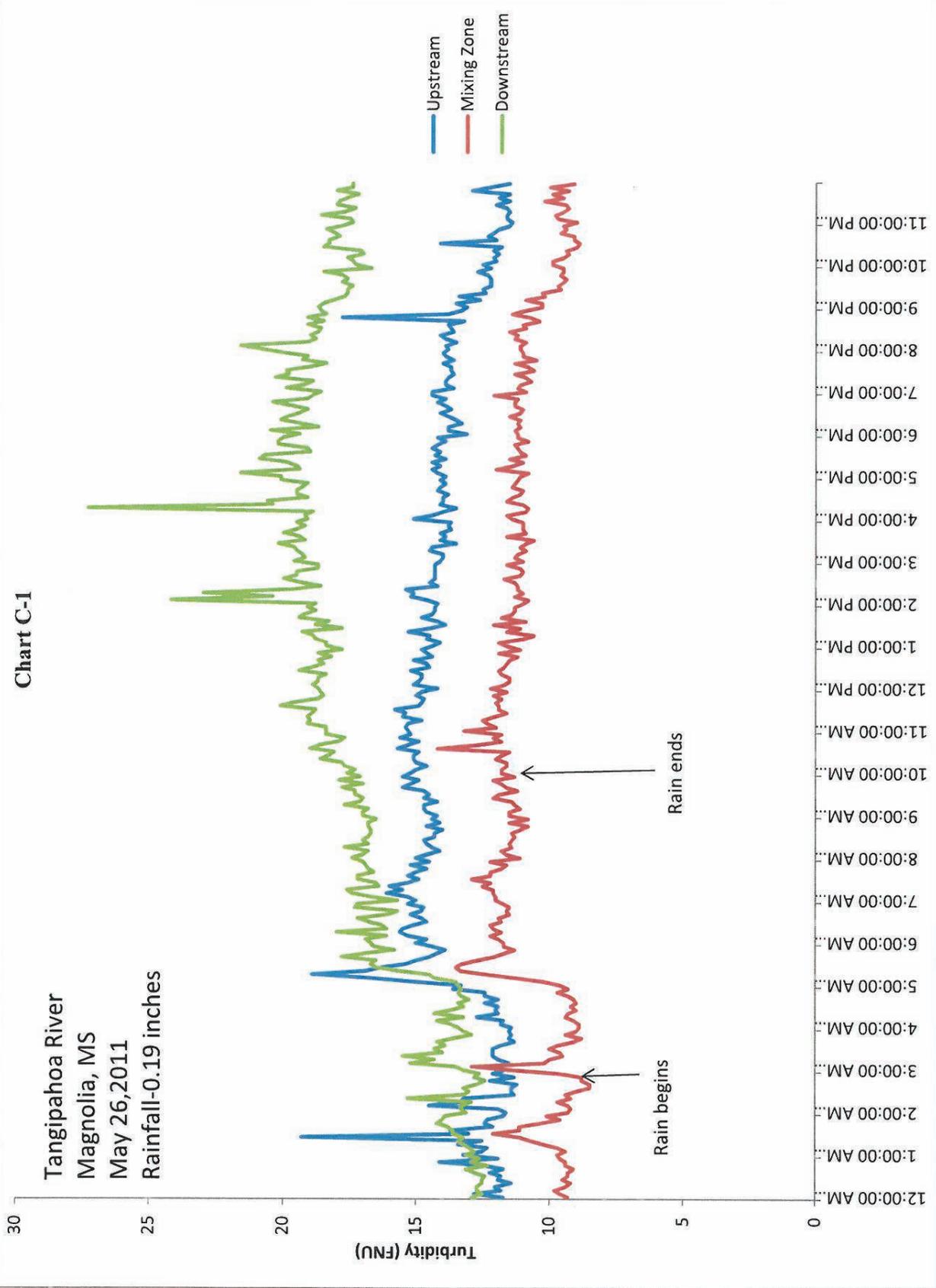
Photo C-5 Rip rap lined banks with silt fence installed at the top



Photo C-6 BMP “train”-waddle, rip rap and silt fence installed

Chart C-1

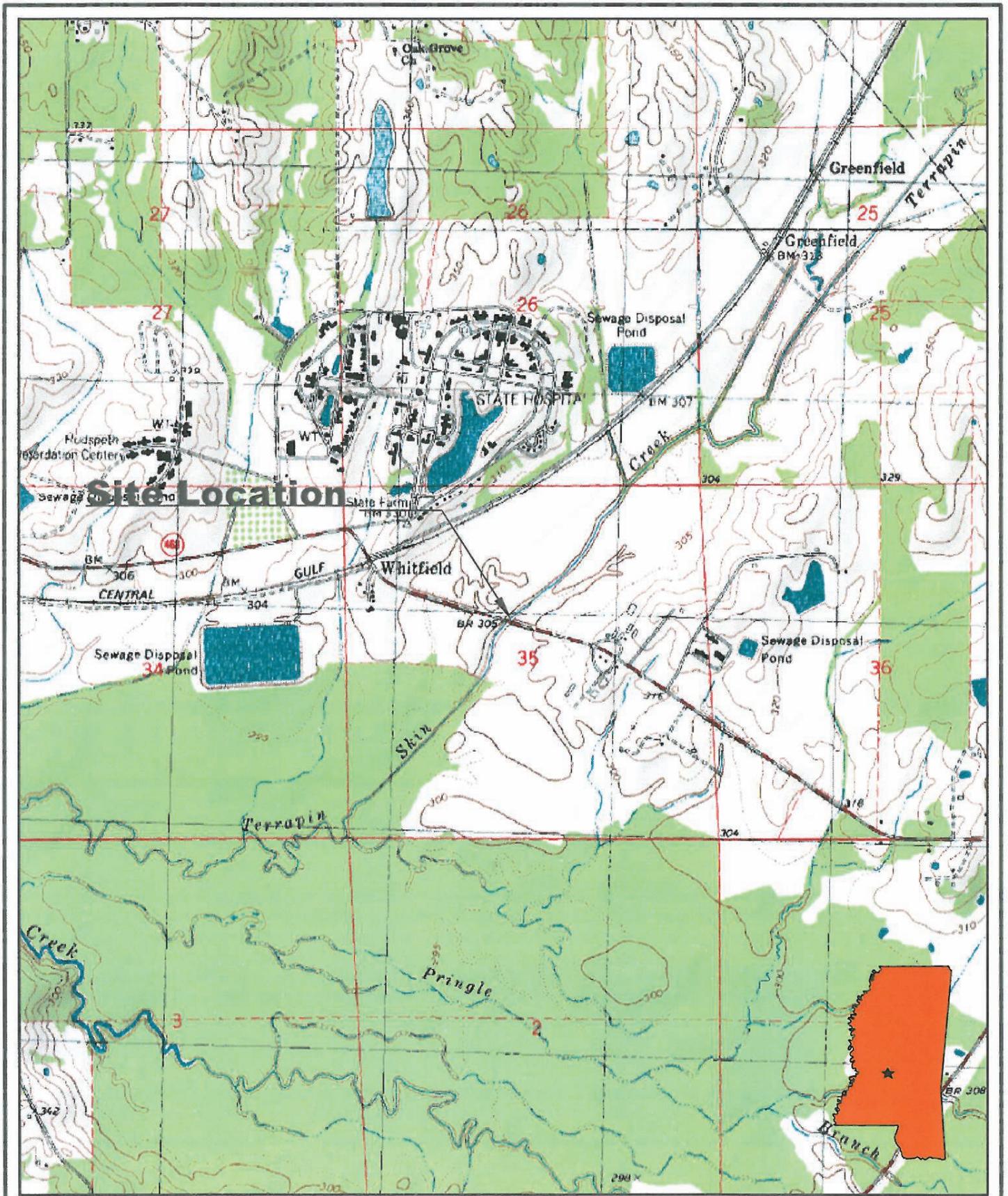
Tangipahoa River
Magnolia, MS
May 26, 2011
Rainfall-0.19 inches



APPENDIX D

Figures, Charts, and Photographs

Terrapin Skin Creek – SR 468 Pearl, Mississippi



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure D-1
 Terrapin Skin Creek
 SR 468 Pearl, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012



MDOT State Study 225
Turbidity Monitoring at Select MDOT
Construction Sites



Figure D-2
Terrapin Skin Creek
SR 468 Pearl, Mississippi

PROJECT NO:
09-2118-0034

DATE:
June 2012

TERRAPIN SKIN CREEK- SR468 PEARL, MISSISSIPPI



Photo D-1 Silt fence lining the stream channel



Photo D-2 Silt fence installed near the top of the stream bank



Photo D-3 Vegetation on stream bank with silt fence installed at the top



Photo D-4 Silt fence in need of maintenance, rip rap enclosed sediment basin



Photo D-5 Silt fence and rip rap installed around a drain inlet

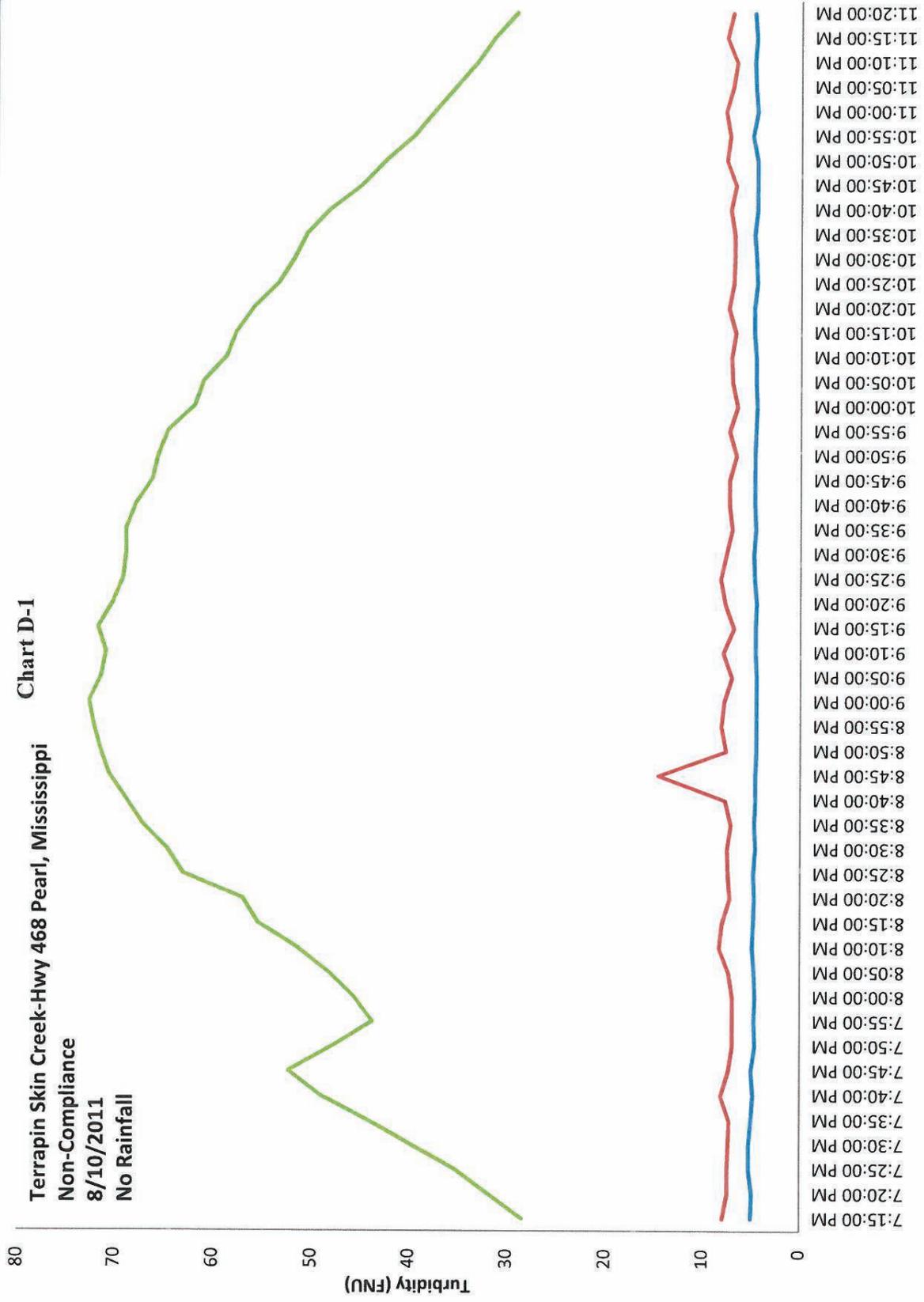
Chart D-1

Terrapin Skin Creek-Hwy 468 Pearl, Mississippi

Non-Compliance

8/10/2011

No Rainfall



Upstream Mixing Zone Downstream

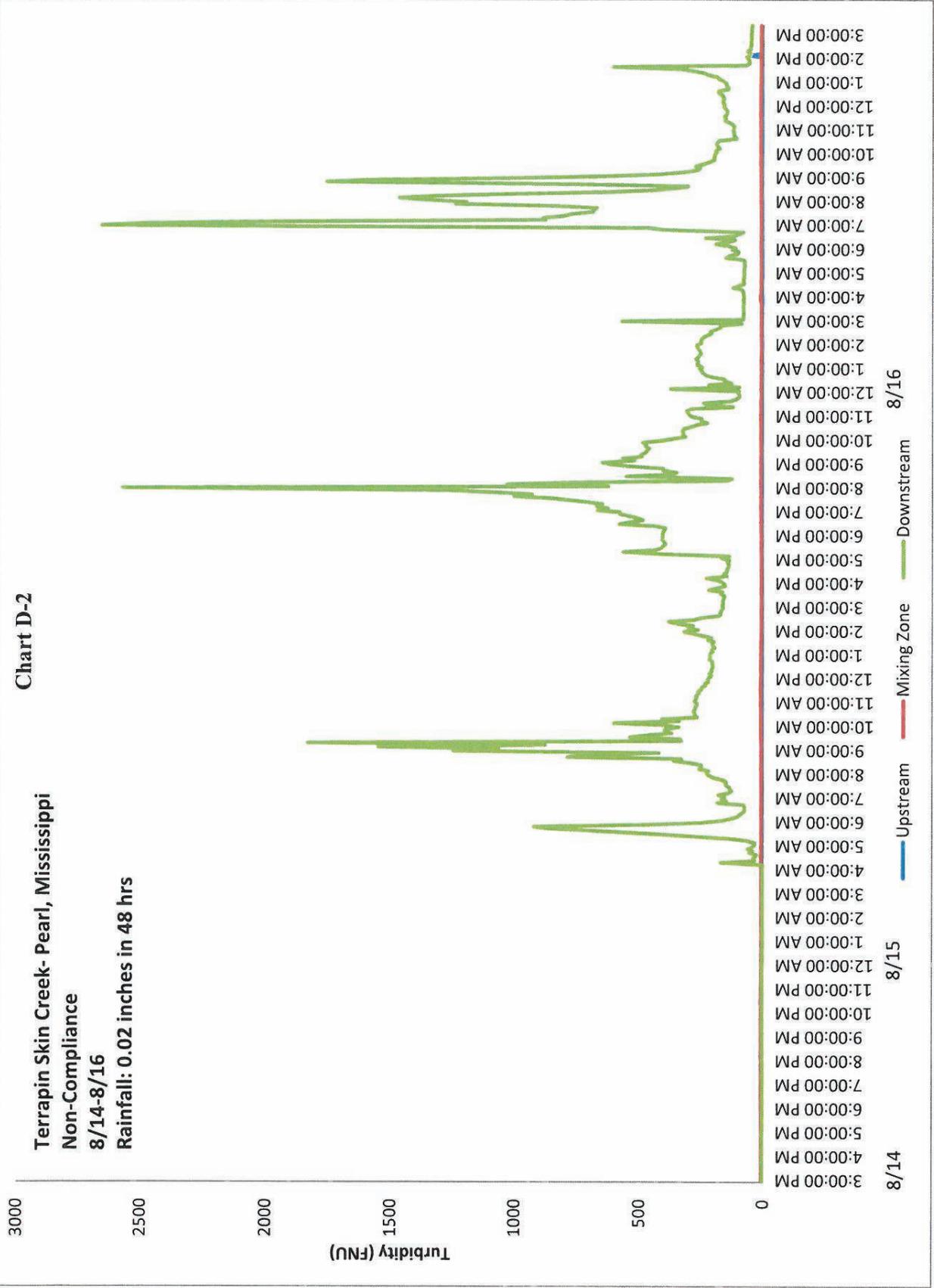
Chart D-2

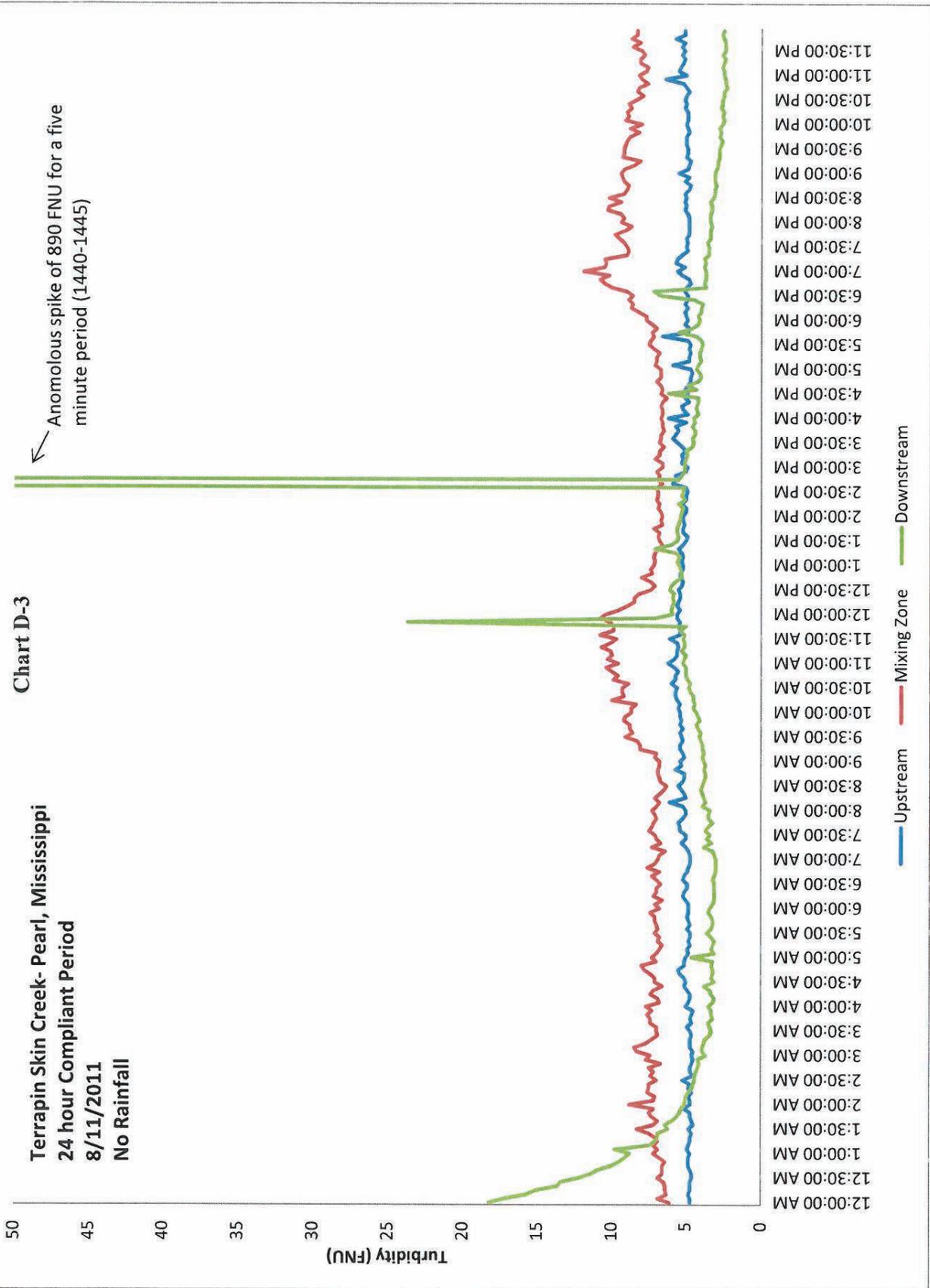
Terrapin Skin Creek- Pearl, Mississippi

Non-Compliance

8/14-8/16

Rainfall: 0.02 inches in 48 hrs

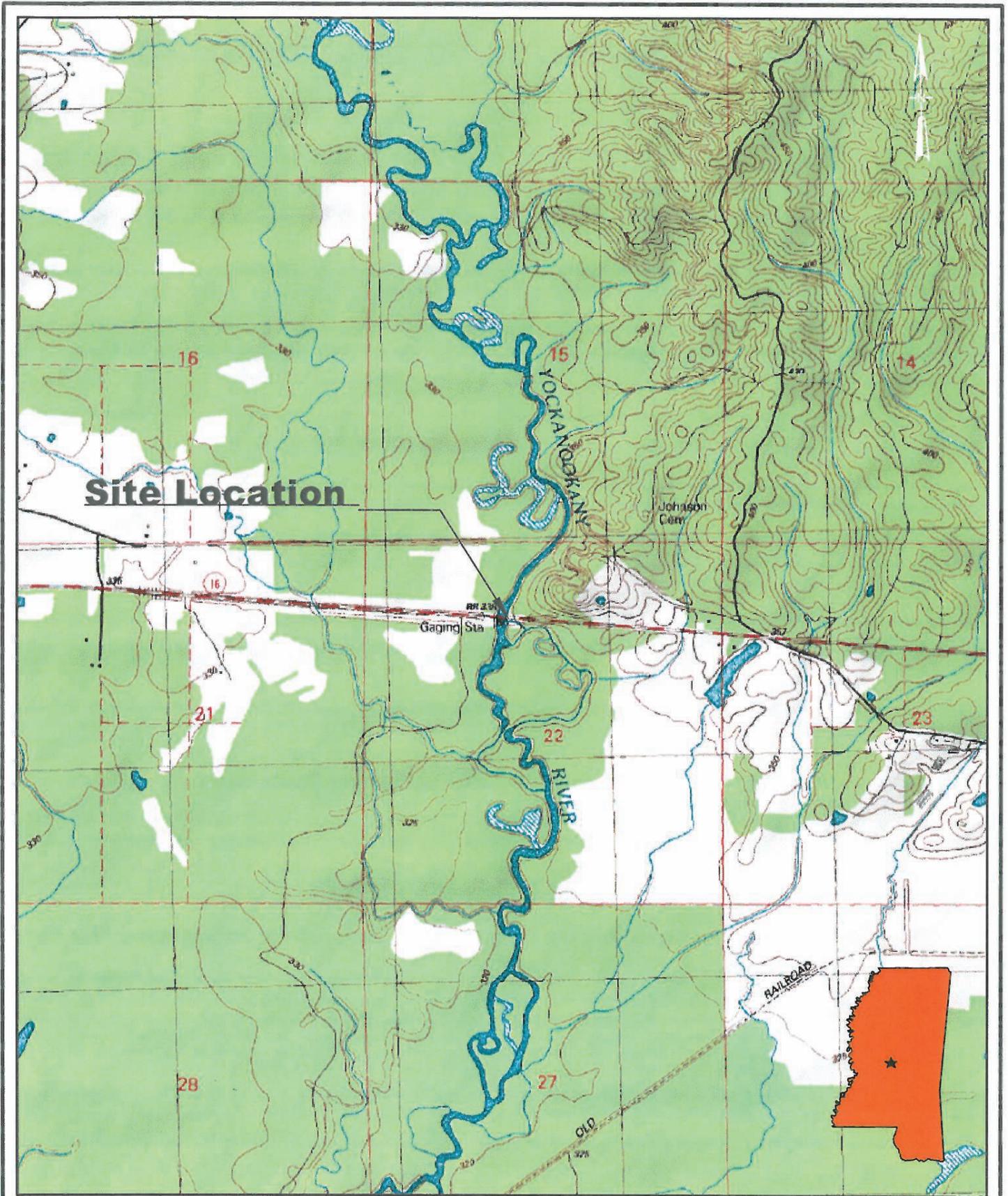




APPENDIX E

Figures, Charts, and Photographs

Yockanookany River – SR 16 Leake County, Mississippi



Site Location

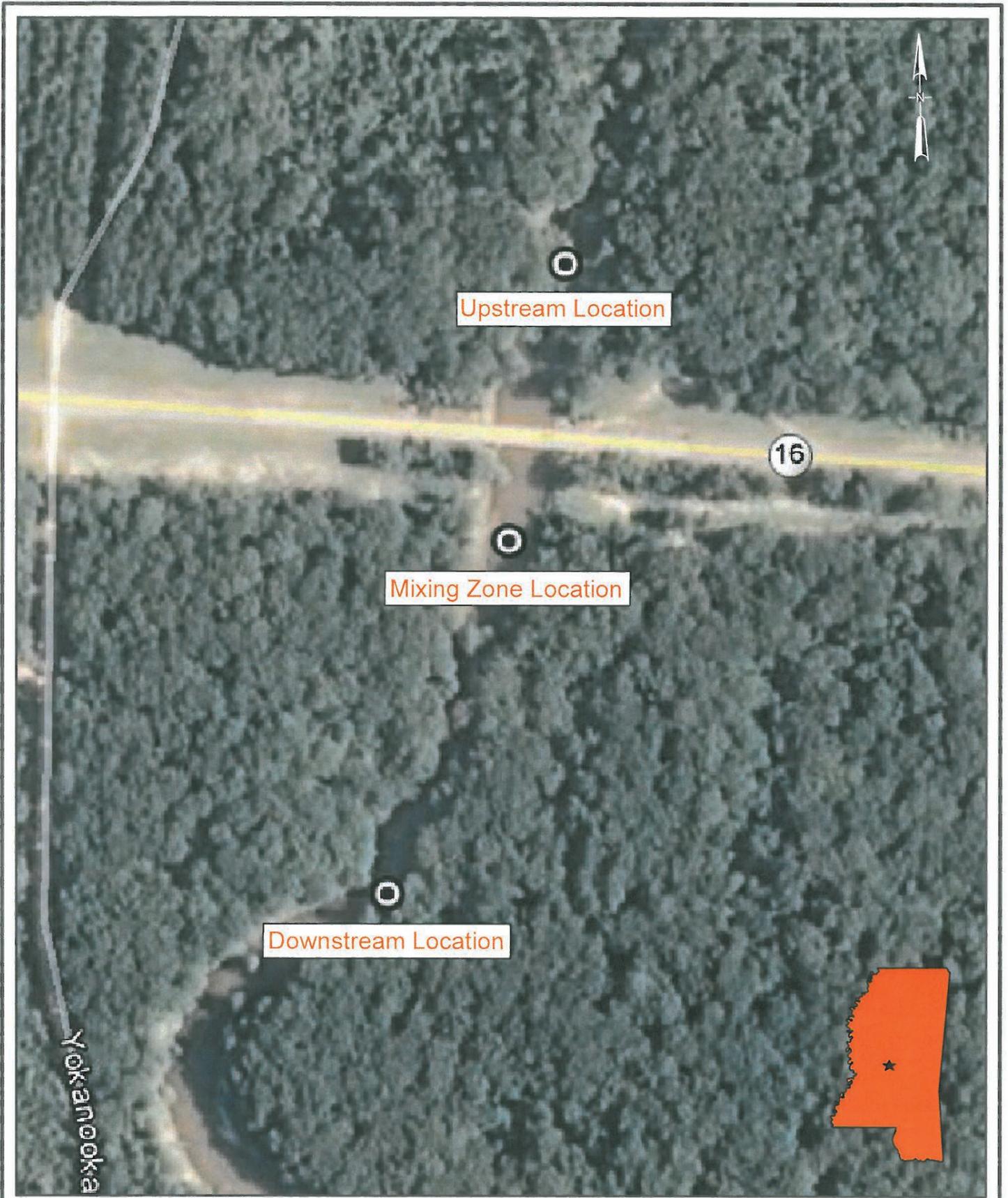


MDOT State Study 225
Turbidity Monitoring at Select MDOT
Construction Sites

Figure E-1
Yockanookany River
SR 16 Leake County, Mississippi

PROJECT NO:
09-2118-0034

DATE:
June 2012



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure E-2
 Yockanookany River
 SR16 Leake County, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012

YOCKANOOKANY RIVER SR 16 LEAKE COUNTY, MISSISSIPPI

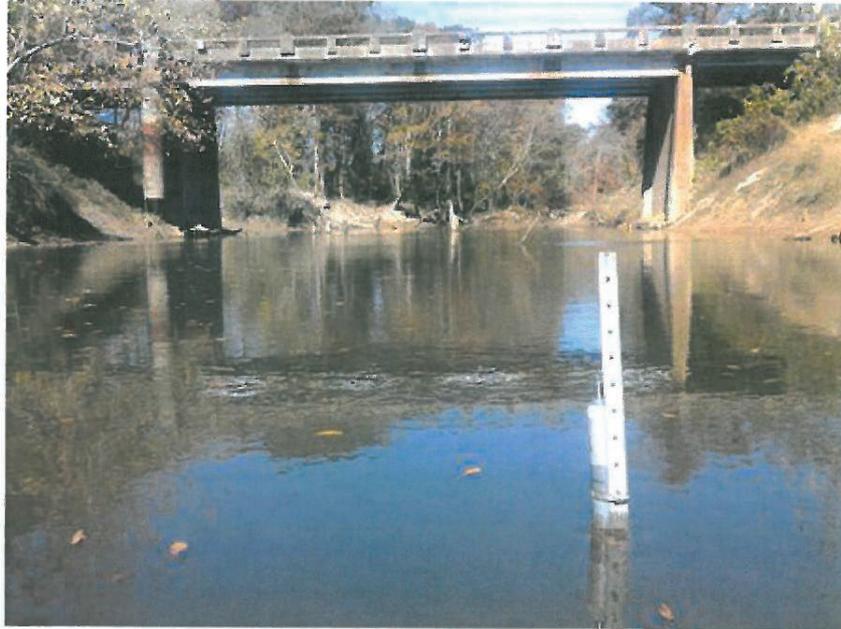


Photo E-1 Troll installed at the mixing zone sampling location



Photo E-2 Natural vegetative cover with mulched slopes and a silt fence installed



Photo E-3 Natural vegetative cover and silt fence installed



Photo E-4 Ditch banks mulched and seeded with waddles installed in the ditch



Photo E-5 Rock check dam installed on the perimeter of the site



Photo E-6 Silt fence installed along the perimeter with slopes seeded or grassed



Photo E-7 Rock check dam at the inlet to a gulley leading to the stream

Chart E-1

Yockanookany River SR 16- Leake County, Mississippi

October 28, 2011

0.17 inches of rainfall

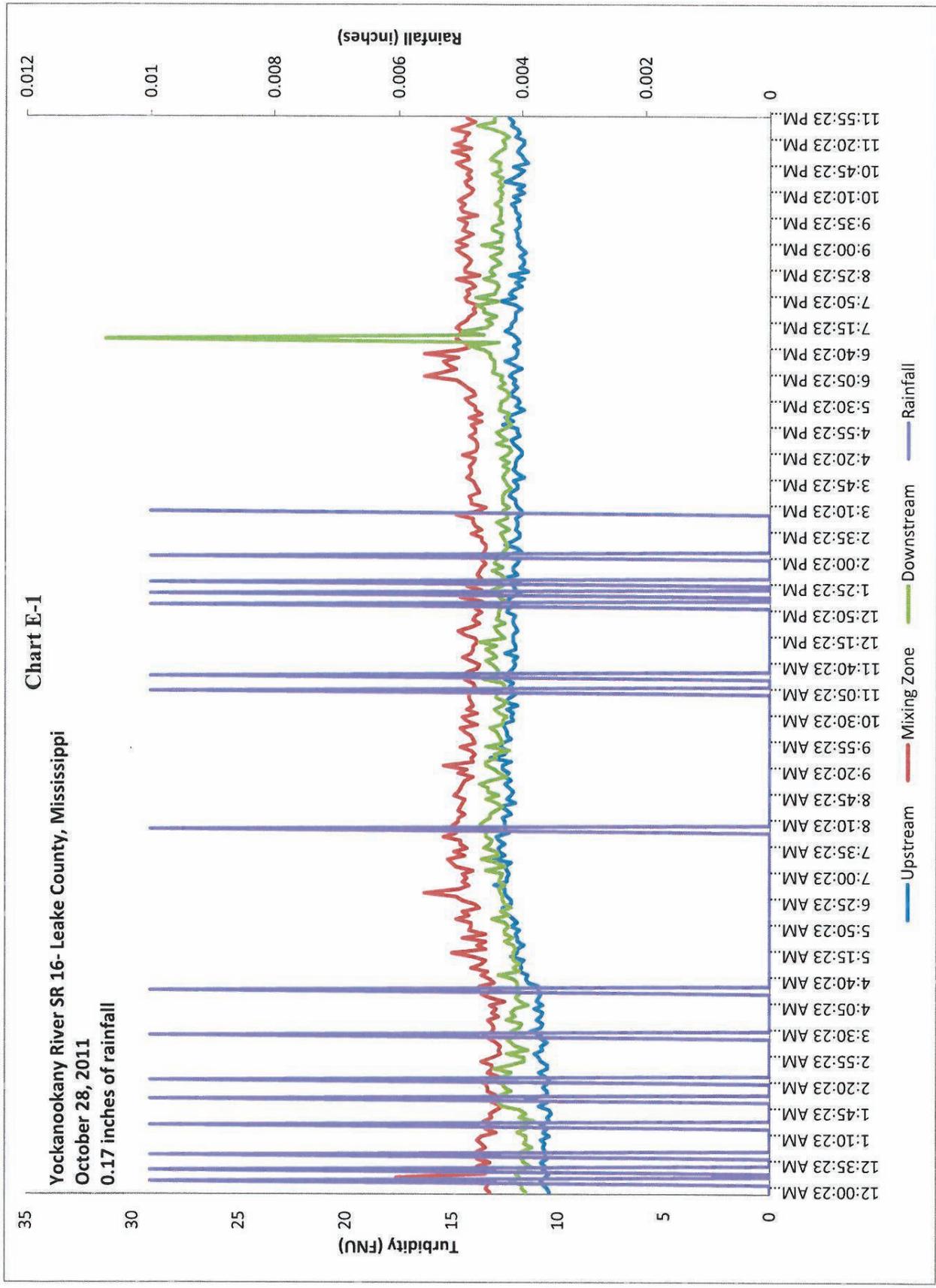
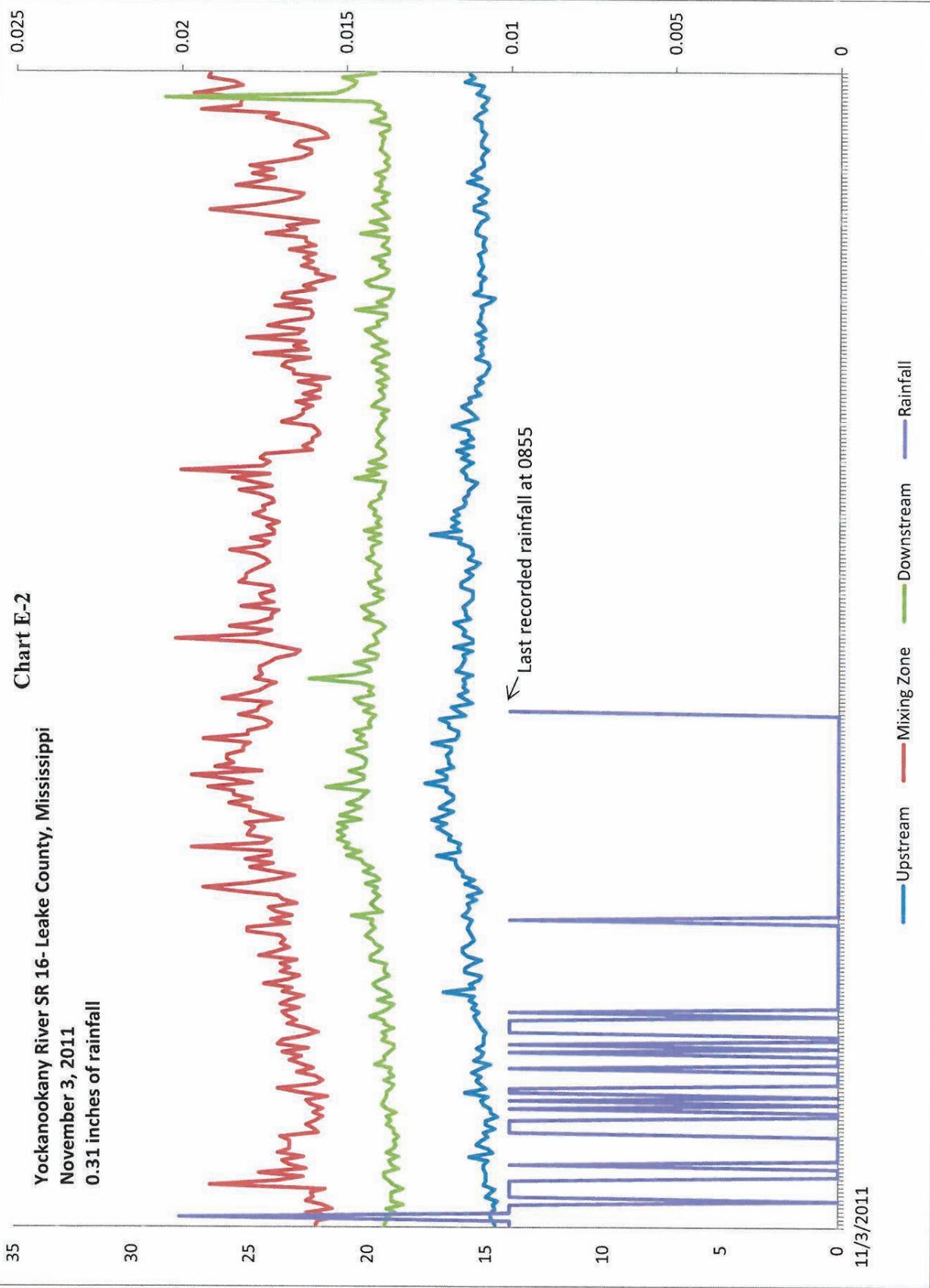


Chart E-2

Yockanookany River SR 16- Leake County, Mississippi

November 3, 2011

0.31 inches of rainfall



Yockanookany River SR 16- Leake County, Mississippi Chart E-3

November 9, 2011

0.16 inches of rainfall

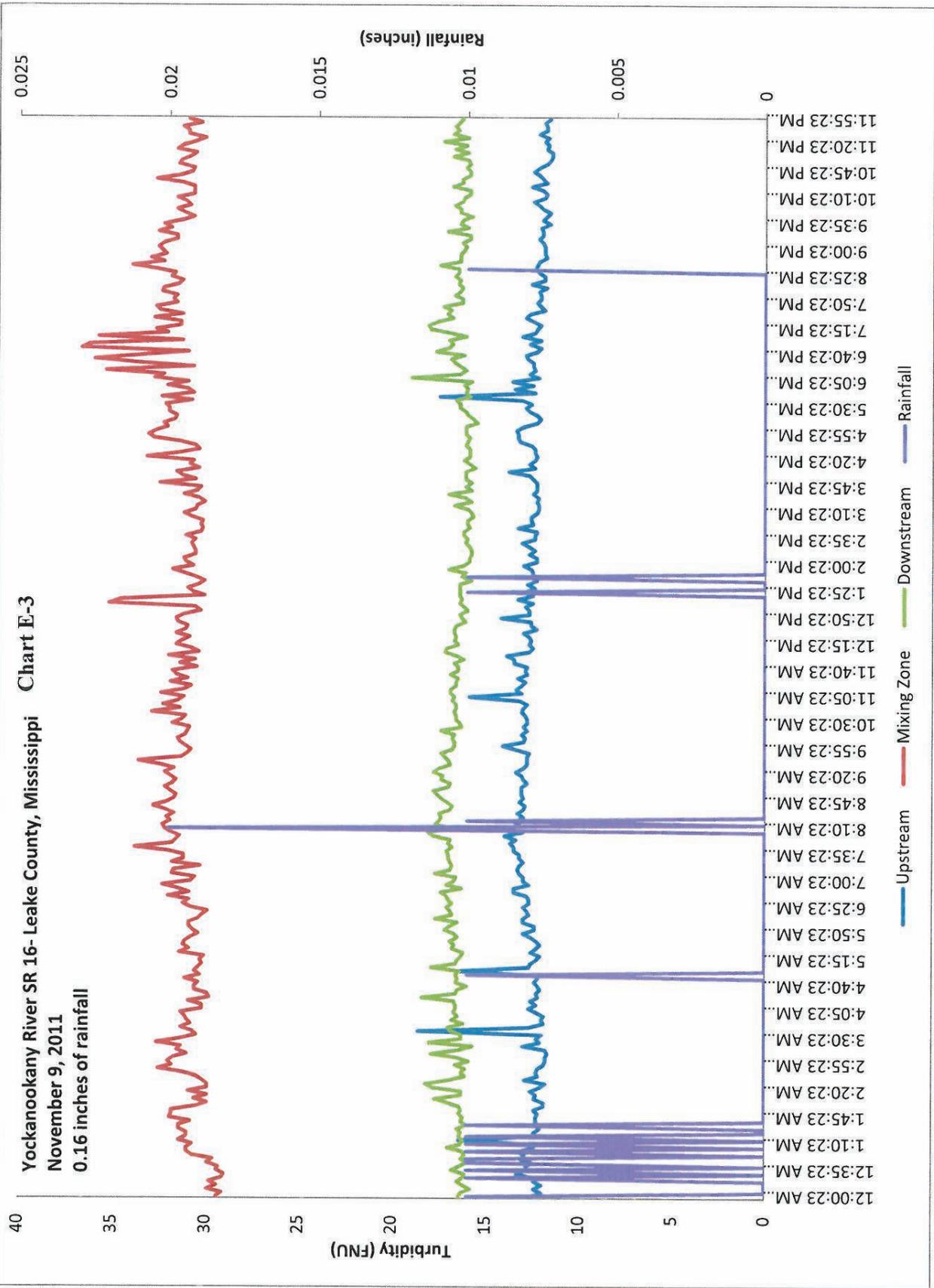
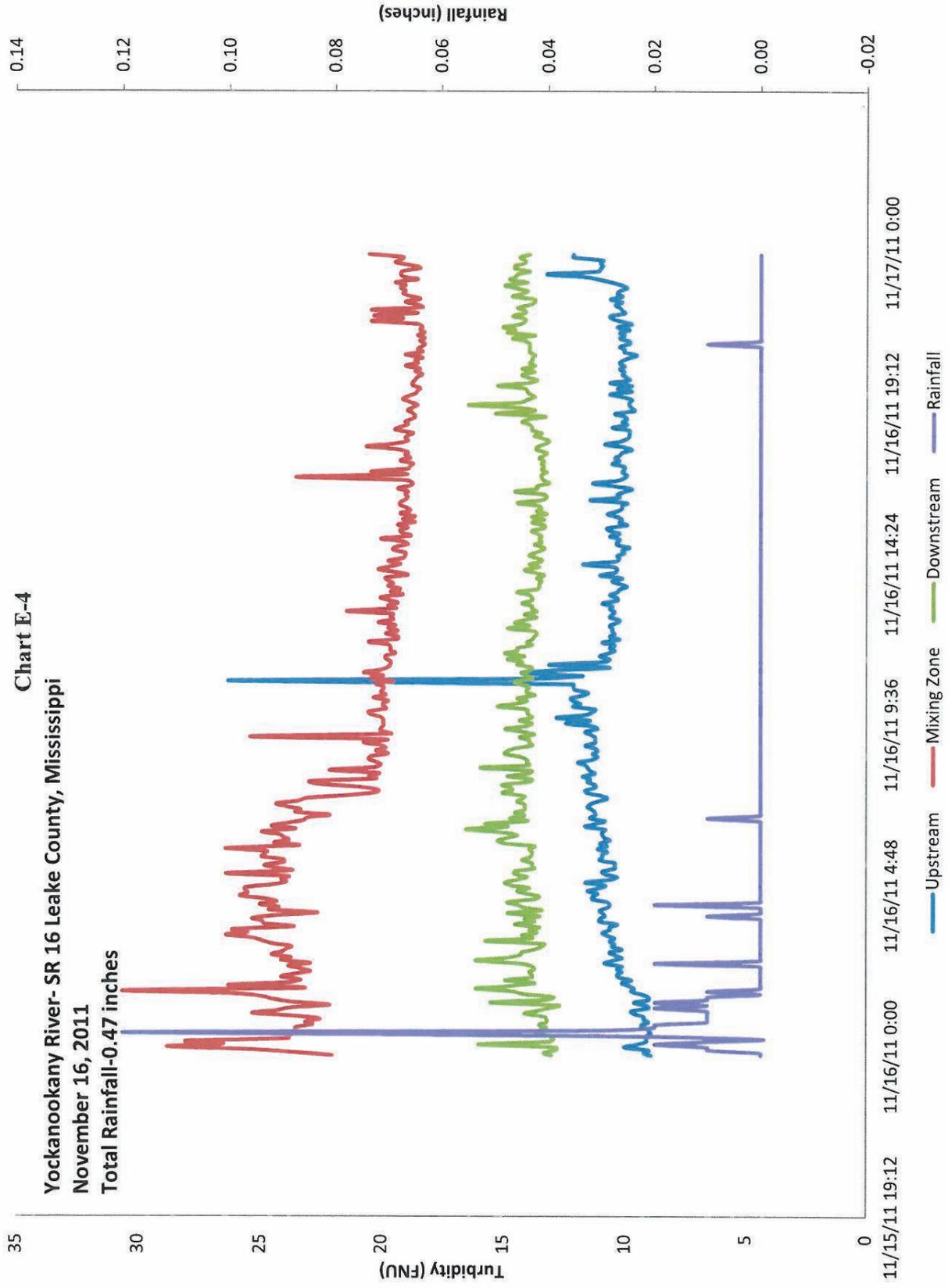


Chart E-4

Yockanookany River- SR 16 Leake County, Mississippi

November 16, 2011

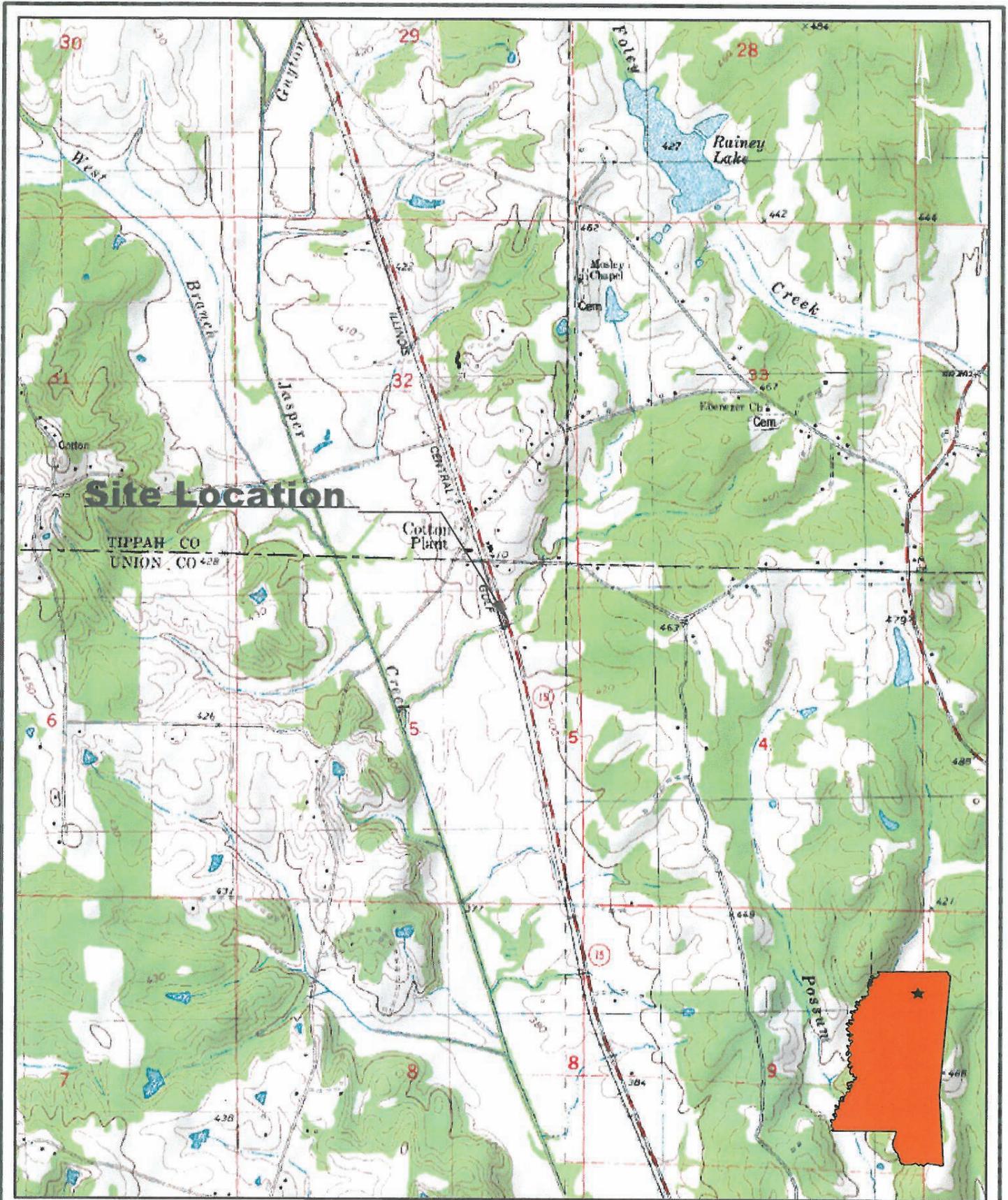
Total Rainfall-0.47 inches



APPENDIX F

Figures, Charts, and Photographs

SR15 New Albany, Mississippi



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure F-1
 SR 15 New Albany, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure F-2
 SR 15
 New Albany, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012

SR 15 NEW ALBANY, MISSISSIPPI



Photo F-1 Troll installed at the mixing zone sampling location



Photo F-2 Mulched slopes and silt fence installed



Photo F-3 Improperly placed hay bales at a drain inlet



Photo F-4 Slopes mulched and silt fence installed



Photo F-5 Lined diversion channel with silt fence installed



Photo F-6 Natural vegetation on slopes with silt fence installed



Photo F-7 Silt fence protecting an existing ditch



Photo F-8 Silt fence in need of maintenance



Photo F-9 Improperly installed hay bales in the stream channel



Photo F-10 Silt fence in need of maintenance

Chart F-1

SR 15 New Albany, MS
Non-Compliance Period
1/25-1/26
1.04 inches of Rainfall in a 24 Hour Period

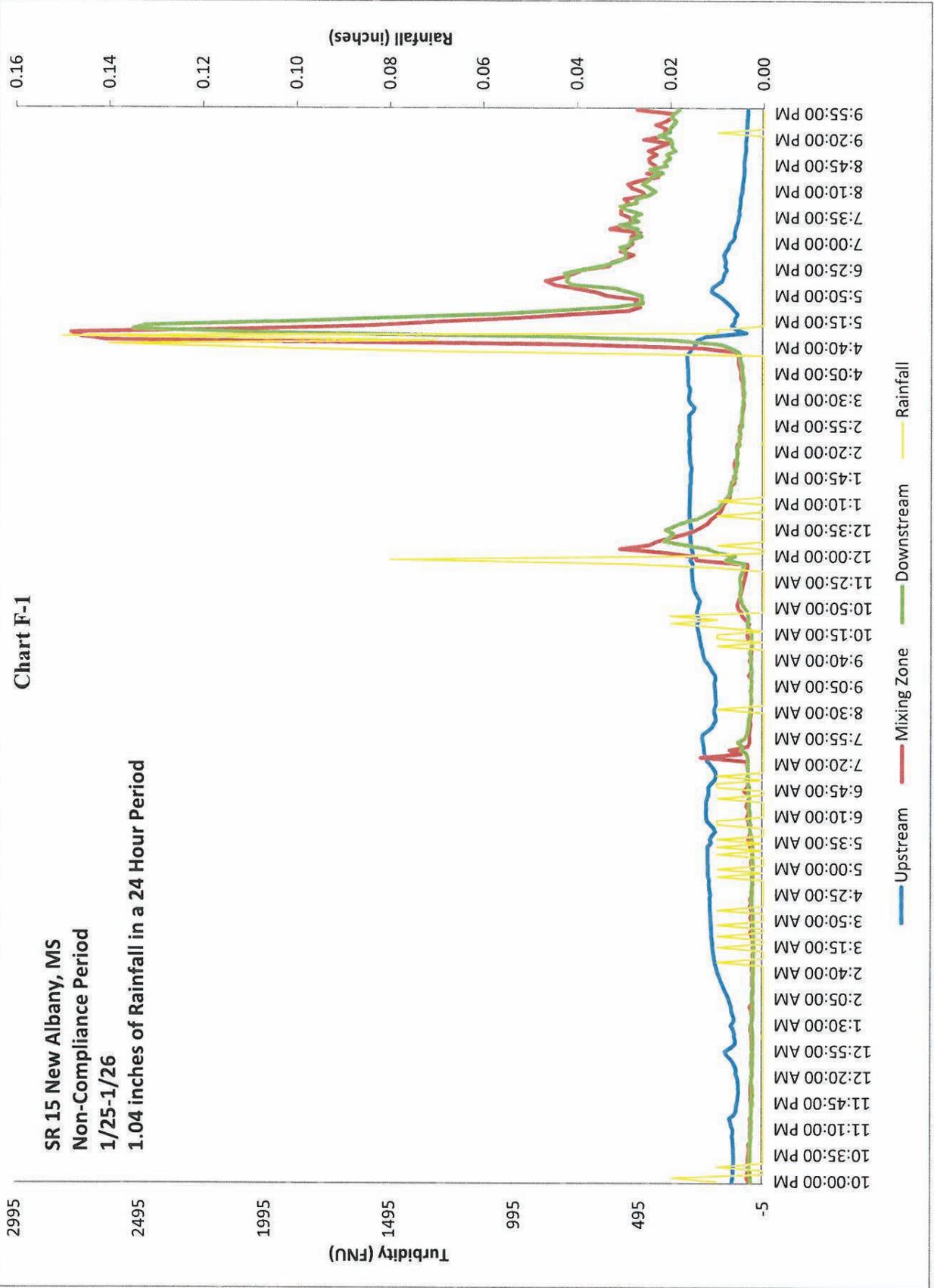
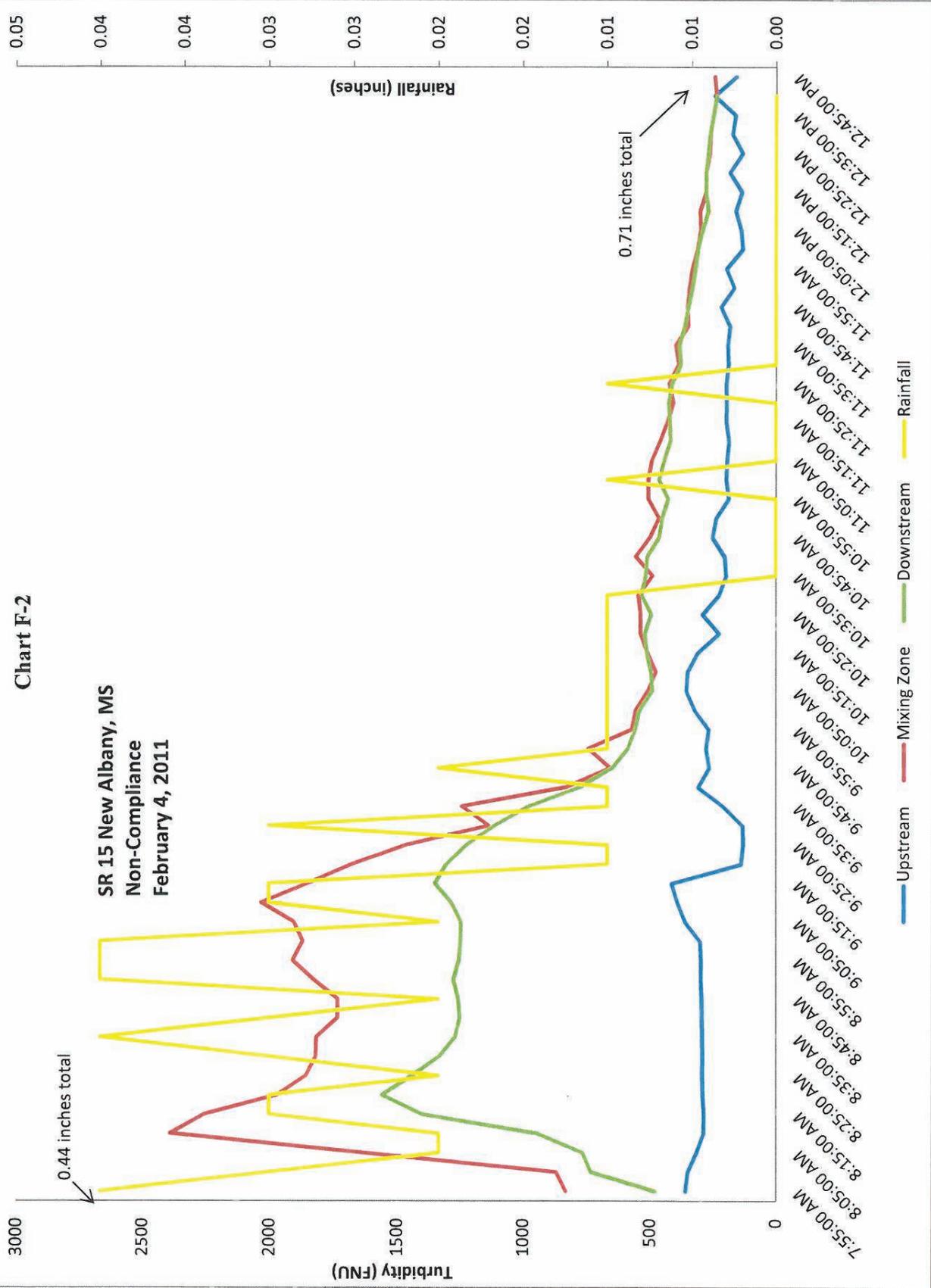


Chart F-2

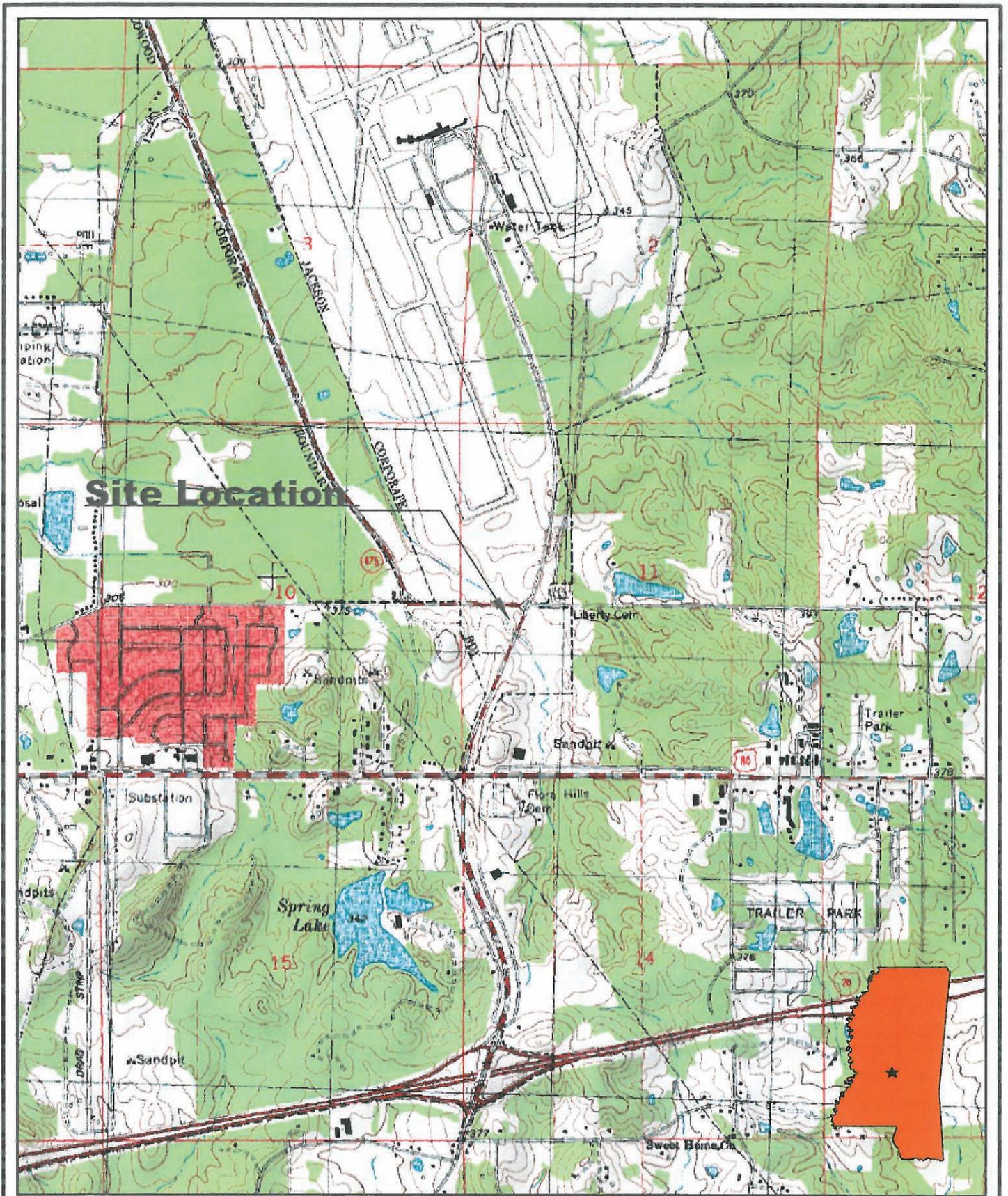
SR 15 New Albany, MS
Non-Compliance
February 4, 2011



APPENDIX G

Figures, Charts, and Photographs

SR 475 Pearl, Mississippi



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure G-1
 SR 475 Pearl, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012



MDOT State Study 225
 Turbidity Monitoring at Select MDOT
 Construction Sites



Figure G-2
 SR 475
 Pearl, Mississippi

PROJECT NO:
 09-2118-0034

DATE:
 June 2012

SR 475 PEARL, MISSISSIPPI



Photo G-1 Rock check dams installed in the ditch adjacent to Old Brandon Rd.



Photo G-2 Troll installed in the mixing zone sampling location



Photo G-3 Slope mulched and seeded with rock check dam installed



Photo G-4 Rock check dam installed near the site discharge point



Photo G-5 Drainage ditch lined with rip rap and grouted



Photo G-6 Seeded and mulched with silt fence installed



Photo G-7 Slopes either grassed or mulched with waddles installed in ditch



Photo G-8 Discharge point

Chart G-1

State Route 475 Bypass Pearl, Mississippi
March 2, 2011
Total Rainfall-0.59 inches

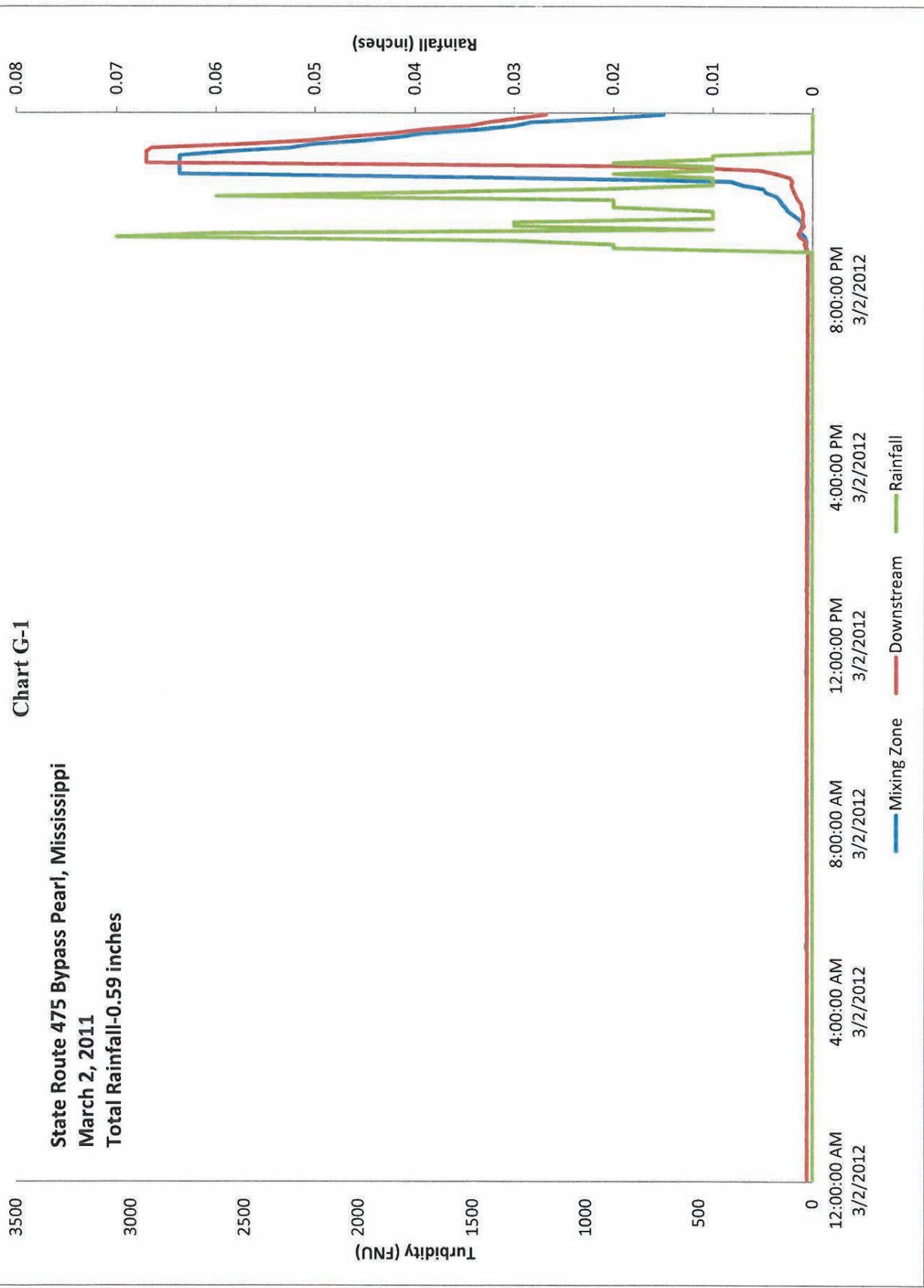
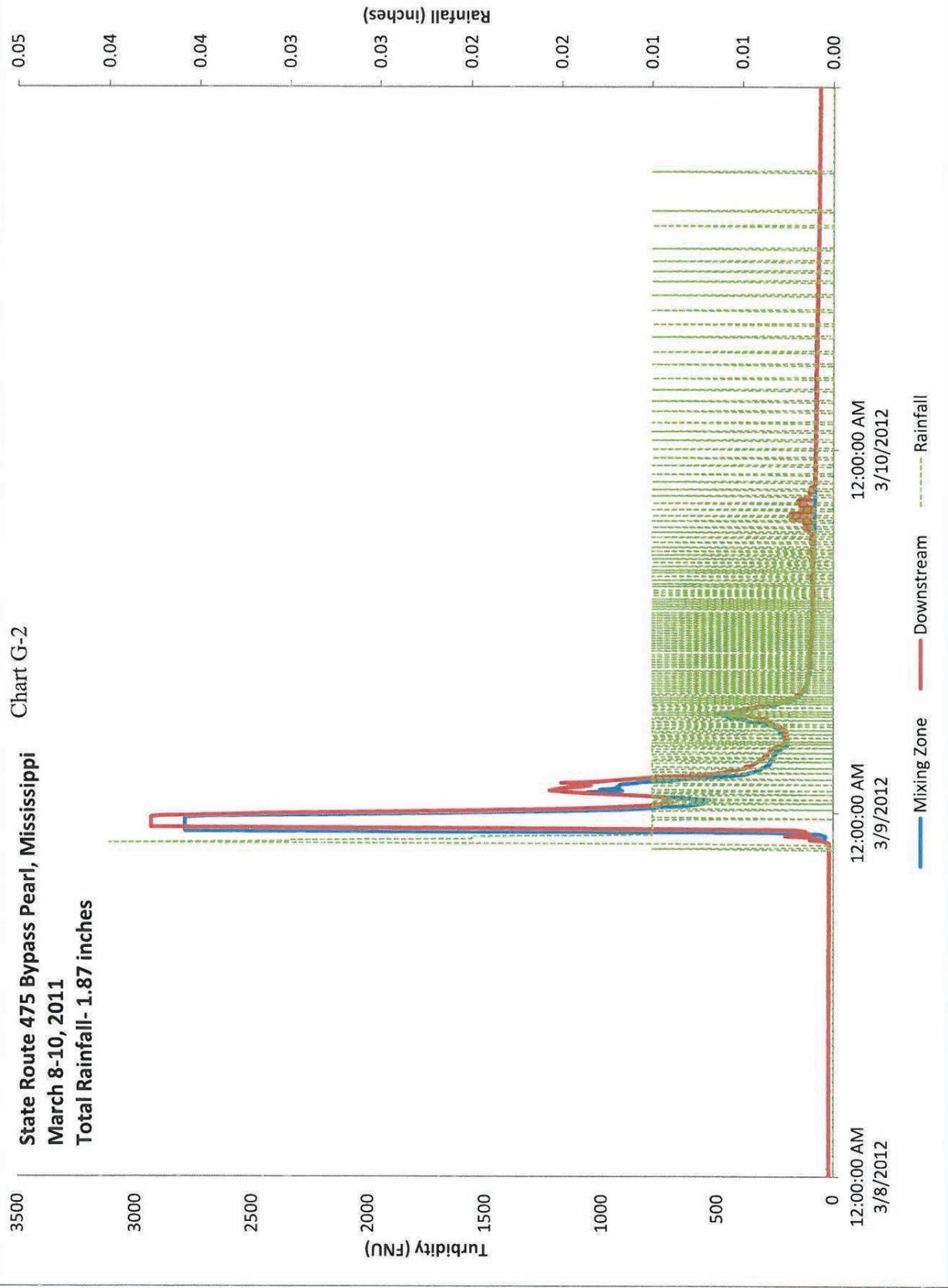


Chart G-2

State Route 475 Bypass Pearl, Mississippi

March 8-10, 2011

Total Rainfall- 1.87 inches

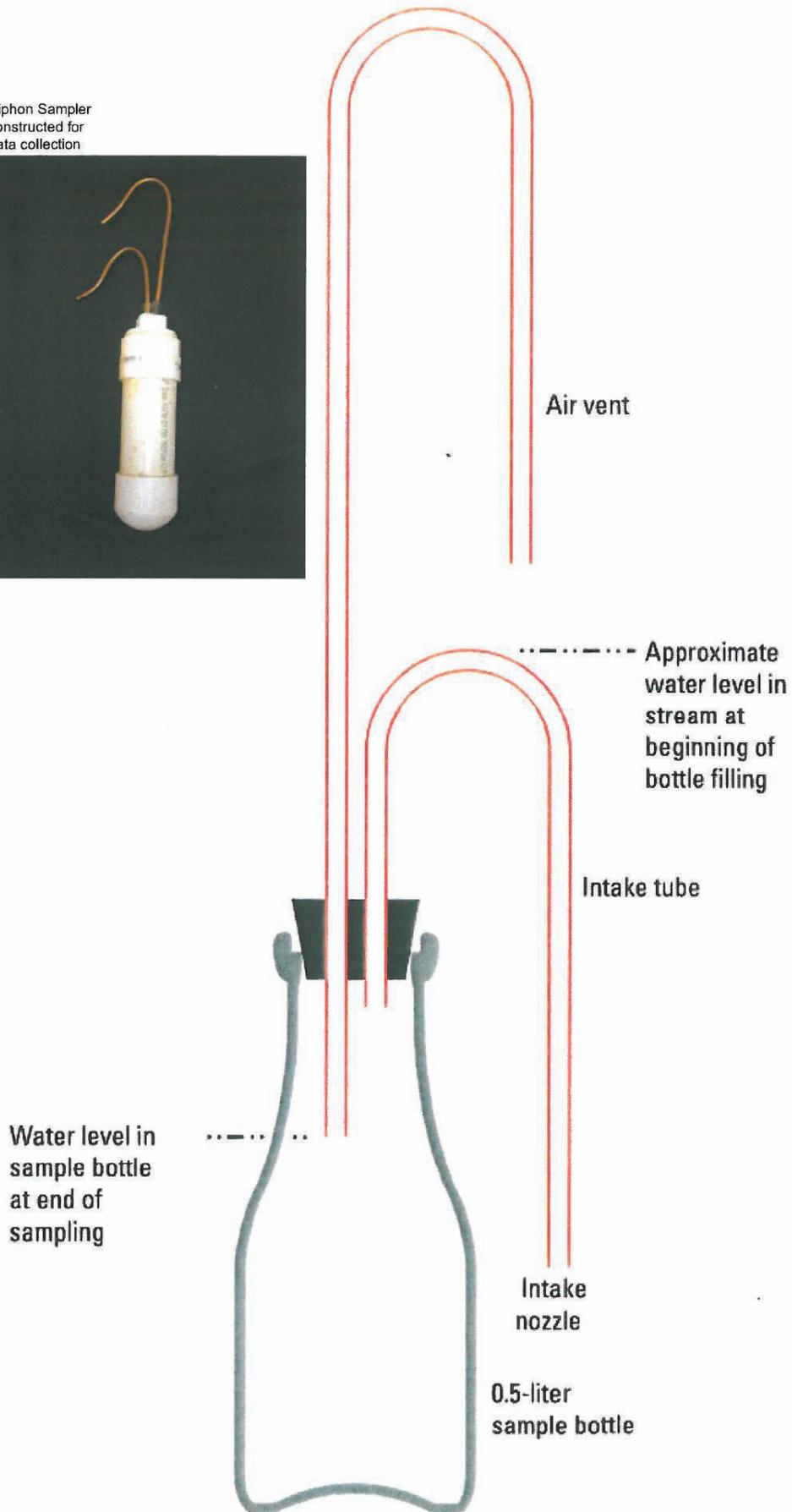


APPENDIX H

Equipment Specification Sheets

Example of Siphon Sampler Construction and Operation

Siphon Sampler constructed for data collection



Air vent

Approximate water level in stream at beginning of bottle filling

Intake tube

Water level in sample bottle at end of sampling

Intake nozzle

0.5-liter sample bottle

WARRANTY

Rainwise, Inc. warrants this RainLog against defects in materials and workmanship for a period of two years from the date of purchase, and agrees to repair or replace any defective product without charge.

This warranty does not cover damage resulting from accident, misuse or abuse, lack of reasonable care, the fixing of any attachment not provided with the product or damage due to a lightning strike. Rainwise will not reimburse for take down or reinstallation charges. Rainwise will not pay for any warranty service performed by a non-authorized repair service and will not reimburse the consumer for damage resulting from warranty service performed by a non-authorized repair service. No responsibility is assumed for any special, incidental or consequential damages. No other warranty written or oral is authorized by Rainwise, Inc. This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state. Some states do not allow the exclusion, incidental or consequential damages, so the above exclusions and limitations may not apply to you.

To return a unit under warranty call 1-800-762-5723. Rainwise will only pay for return shipping charges using the method of their choosing. If expedited shipping is requested, the excess cost must be paid by the customer. Make sure that the equipment is properly packed... preferably in the original box, damage incurred in shipping is not covered by this warranty.

CUSTOMER SERVICE



Rainwise Inc.

P.O. BOX 443 - BAR HARBOR, MAINE 04605-0443 - (207) 288-5169

Service Department:

Ph: 1-800-762-5723

Fax: 207- 288-3477

Email: service@rainwise.com

Visit the Rainwise web site www.rainwise.com for latest information and updates.

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V: 1:1 : 21/03/07

RainLog™

Annual Rainfall Data Logger

Instruction Manual



Rainwise Inc.

P.O. BOX 443 - BAR HARBOR, MAINE 04605-0443 - (207) 288-5169

INTRODUCTION

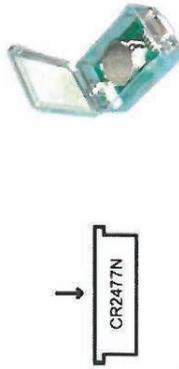
The RainLog in combination with the Rainwise Rain Collector constitutes a stand alone rainfall measuring and recording system. The RainLog has a large, non-volatile memory that is capable of recording one year of rainfall with a one minute resolution. A single CR2447N lithium battery powers the unit and in most cases will last one year. Data stored in memory will not be lost during a battery change.

The RainLog continually monitors for rainfall events and at the end of each minute stores the minute rainfall to non-volatile memory. The RainLog makes efficient use of the available memory by only storing information when an event has occurred.

INSTALLING THE BATTERY

One CR2477N lithium battery is supplied separately with each RainLog. Please contact Rainwise for additional replacement batteries.

1. Lift the RainLog's cover up from the serial port side as illustrated below and insert the battery as shown.



2. Close the cover and turn the RainLog upside down. You should see a red LED glow for 8 seconds. After 8 seconds the LED will switch off, it will then flash faintly once every 8 seconds. This indicates that the logger is running.

Date sequence error.

A date sequence error occurs when the RainLog has logged information and then had its clock set to an earlier date. To reduce the risk of this happening, it is advised that you download the data from the RainLog, save it to file, set the clock and then clear it.

The RainLog is not recording rainfall.

Verify that the rain collector is clean and that the drain hole in the center is not blocked. If you remove the screen, make sure that you bend the cotter pin legs back up when you put it back. Leaving the legs down will stop the tipping bucket from tipping.

If the collector is not blocked, verify that the RainLog can read the mechanism. Set the RainLog's clock and clear its memory using the RL-Loader application. Connect the RainLog to the tipping bucket and tip it by hand 5 times. Wait 1 minute and then download the data. A new record should appear with 5 counts. If no records appear, disconnect the RainLog from the collector and short the two rainfall input terminals on the RainLog with a small screw driver several times. Wait 1 minute and download again. If you see new records, then there is likely a fault with the collector. A continued absence of records may indicate a RainLog failure. Contact Rainwise Support for further assistance.

downside to this method is that it makes graphing more difficult as the time interval is random.

Exporting Graphs:

Make sure that the graph window is the active window.

Copy the graph using the Copy button or click the right mouse button and select Copy.

The graph is copied as a Windows Meta File. This offers the advantage over the Bitmap format in that the object may be scaled in the destination application.

The graph can now be pasted into any application that supports wmf cutting and pasting (Microsoft Word).

TROUBLESHOOTING

The computer won't detect the RainLog.

The RL-Loader must connect to a free available serial port. If you get the "No devices found!" message within a couple of seconds after clicking the Auto detect button, then chances are there are no free ports available. The computer will scan all available ports looking for the RainLog. The scanning window will indicate which ports is being scanned.

Check the following:

- Certain programs like Palm Hot Sync can hold serial ports open, make sure they are not running.
- If you are using a USB-to-Serial adapter make sure that it is installed correctly. Use the Windows Device Manger to verify that a com port has been created.
- Make sure that the LED on the RainLog is flashing every 8 seconds, this indicates that the RainLog is running.
- Check the serial cable connections.

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CONFIGURING THE RAINLOG

The RainLog must be configured prior to use. This is done by connecting it to a PC and running the RL-Loader software provided with the unit. A serial RS-232 cable is provided with the RainLog. This cable must be used to connect the RainLog to the computer. A USB-to-Serial adapter may be required if your PC is not equipped with a serial port. These adapters can be purchased from Rainwise.

1. Install the RL-Loader software by inserting the RL-Loader CD-ROM. The install should begin automatically. If it does not, run "setup.exe" on the CD.
2. Make sure the RainLog is correctly attached to the PC and then run the RL-Loader application.
3. From the "Settings" menu select the appropriate type of collector. The 0.25 mm/tip setting is the metric equivalent of the 0.01 in/tip collector (standard).
4. Connect to the RainLog by clicking the "Auto Detect" button  or select "Auto Detect" from the "Logger" menu. RL-Loader will begin scanning available ports for the RainLog.
5. Once connected, the "Device Info" window will show the status of the RainLog. Click the "Set Logger Clock" button  or select "Set Clock" from the "Logger" menu. The RainLog's clock and calendar will be set to match the PC.
6. You may assign the RainLog a text ID. This ID helps manage

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data from multiple RainLog's. Click the "Set ID" button or select "Set ID" from the "Logger" menu. Enter a name **ID** when prompted. The "Device Info" window will update.

7. Clear the RainLog's memory by clicking the "Clear Ram" button  or select "Clear Ram" from the "Logger" menu.
8. Close the RL-Loader application and disconnect the RainLog. The logger is now configured and can be connected to the rain collector.

INSTALLING THE RAINLOG

The RainLog is now ready to be installed in the rain collector. Make sure that the collector has already been securely mounted and is level. Readings will not be accurate if the collector is not level.

1. Loosen the 4 screws securing the top of the collector to its base.
2. Twist the collector top counter clockwise to free the tabs. Lift the top off and set it aside.
3. Remove the blue cap on the base and carefully pull the connector out of the tube.
4. Connect the RainLog to the connector and place the RainLog in the tube. Replace the blue cover.



Data and graphs can be exported to other Windows applications using the clipboard. The new export feature in version 2.1 uses OLE to export data directly into Microsoft Excel.

Exporting Data :

Data may be exported directly into Microsoft Excel. Excel must be installed for this feature to work. Click the Export button or select Export from the File menu. Data can be exported in three different ways:

Report by Day:

This will export daily rainfall totals into Excel. The range of data can be specified using the begin and end date selectors.

Report by Minute:

Data will be exported by minute. Minutes with zero rainfall will also be exported. Depending on the selected time span this method can create a very large spreadsheet. Excel is limited to 65535 rows which equates to approximately 45 days of one minute data. Before exporting, you will be prompted to first confirm that you wish to proceed. Second, you will be asked if you wish to remove inactive data. If you elect to use this inactive data removal feature, then all periods of 3 hours or more that had no rainfall will not be exported. The first rainfall record after this inactive period will be flagged with a comment "New rainfall event". The advantage of using this feature is the elimination of large portions of data that contain no rainfall while still maintaining true one minute resolution for each rainfall event.

Report Events:

This method exports one minute rainfall events without any padding. No zero rainfall records will be exported. This makes the output very compact and only contains relevant rainfall data. The

Daily data in the Text window. By default, all of the data in the Daily text window is displayed. The graph can be customized to show different ranges.

To graph a specific range of data, select (highlight) the desired Daily data in the Text window. Right click your mouse and select Graph from the pop-up menu. The graph will update showing only the select data.

The graph can be copied and pasted into other applications. The graph is copied as a Windows Meta File image.

Working With Saved Data

Data from the RainLog can be saved to disk. The saved file can be loaded back into RL-Loader at any time for analysis and for creating reports. When saving data to file you can either create a new file or append the data to an existing file. Appending data is useful for keeping track of rainfall from one particular logger for extended periods. If you are working with multiple RainLog's, it is recommended that you save data to files using the same name as the loggers ID. This way it is easy to keep track of what data belongs to what logger. If you are using two RainLog's with one collector, give the RainLog's unique ID's and save data to a common file. For Example, call the loggers "City Hall 1" and "City Hall 2". Save the data to a common file "City Hall".

Important for Version 2.0 Users:

Version 2.0 saved data to files by default with the extension ".csv". This has been changed to ".dat" in version 2.1. You can still load version 2.0 files, but you must change the file type in the window that prompts you for a file name.

Exporting Data



5. Re-attach the collector top and tighten the four screws.

INSTALLING THE RAINLOGGER (If Applicable)

The RainLogger package consists of a RainLog data logger, rain collector and mounting post.

1. The mounting post is shipped in two sections. Screw the sections together by hand.
2. The post should be buried to a depth of 16 inches.
3. Remove the top of the collector by loosening the 4 securing screws.

To ensure accuracy, the bubble level inside the collector should be used to level the gauge.

RETRIEVING DATA FROM THE RAINLOG

The system is now ready to collect data. After removing the RainLog from the collector, connect it to a PC using the serial cable provided.

1. Run the RL-Loader application. Click the "Auto Detect" button  or select "AutoDetect" from the "Logger" menu.
2. Click the "Download" button  or select "Download" from the "Logger" menu. The text and graph windows will update once the download is complete.
3. The downloaded information should be saved to disk. Select "Save As..." from the file menu. Select a meaningful file name and save the file. This file can be opened again at a later time. You also have the option of appending data to this file. This means that you can maintain one file per RainLog.

RL-LOADER SOFTWARE

Overview

RL-Loader is a Windows based application that was designed to easily extract and manage rainfall data collected by the RainLog data logger. Data can be viewed in a text or graphical format.

The basic methods for connecting and extracting data from the Rainlog are covered in previous sections of this manual. Three primary windows are available in RL-Loader. The following sections explain each in detail.

The Device Info Window:

This window provides information about the status of the RainLog. The information displayed is only valid when a RainLog is connected. The following information is presented:

Name: ID string (user configurable).

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Status: Connection status, "Connected" or "Not Connected".
Time: Device time.
Date: Device date.
Version: Device version.
Memory: Device memory size in kilobytes
Capacity: Amount of memory used.

The Text Window:

The text window displays rainfall data in a sequential list. There are two modes, Event and Daily.

Event shows individual rainfall event records. This is the format used by the RainLog. When data is downloaded from the RainLog, a final entry is added that contains the current PC time/date with a 0 rainfall count. This is used to set the end of logging for reports and graphing.

Daily shows rainfall by the day and includes days when there was no rainfall. This data is computed from the event records. All graphs are based on the daily data. The first entry is based on the date when the unit was last cleared. This is assumed to be the start of logging. Error messages are appended to records when there is a calculated date/time sequence error. All or part of the text data can be copied using the Windows Clipboard. Use the menu options under "Edit" to select and copy data. Once the data is in the clipboard it can be pasted into any Windows application that supports cutting and pasting.

Important: Right click in the text window to get a pop-up menu that will allow you to copy, select and graph selected portions of data.

The Graph Window:

The Graph window provides a graphical representation of the

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RAIN GAUGE – Polypropylene



The RainWise model RGP industrial tipping bucket rain gauge is constructed to provide accurate recording of rainfall data at a reasonable price. The 8" diameter collector meets NWS specifications for statistical accuracy.

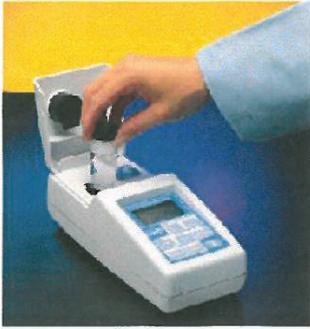
The tipping bucket causes a reed switch to close with every increment of rainfall. This may be used in a system to determine either rainfall amount or rate. The gauge is equipped with a built-in level to aid in installation. A insect/debris screen is provided. The gauge is furnished with 50 feet of buriable cable.

The model RGP is guaranteed for five years.

SPECIFICATIONS

Housing:	High Impact Polypropylene.
Transducer:	Tipping bucket of specially formulated plastic for low surface tension
Switch:	Dry reed switch.
Output:	Less than 0.1 sec. switch closure.
Capacity:	6 to 24 VDC @ 500ma
Resolutions available:	0.01 inches, 0.25 mm, 0.2 mm, 0.1 mm
Accuracy:	1.5% at 0.5 per hour





With a measurement range of 0 to 1000 NTU and a resolution of 0.01 NTU, the 2100P is ideal for regulatory monitoring, process control or field studies.



The 2100P Portable Turbidimeter brings laboratory-level performance on-site, offering fast, accurate results and the ease-of-use analysts demand in the field.



The 2100P Portable Turbidimeter comes with all the necessary testing apparatus, an instrument and operations manual, and a durable carrying case.



The farther you get from the lab, the more you'll appreciate the lightweight (2.7 kg or 6 lb) portability of the 2100P. Durable carrying case for convenient transporting is provided.



ISO 9001 Certified

2100P Portable Turbidimeter

FOR LABORATORY PERFORMANCE IN THE LAB AND IN THE FIELD



The 2100P Portable Turbidimeter offers a level of performance previously possible only with laboratory instruments. The 2100P combines microprocessor-controlled operation and Hach's patented Ratio™ optics to bring greater accuracy, sensitivity, and reliability to field testing.

The two-detector optical system compensates for color in the sample, light fluctuation, and stray light, enabling analysts to achieve laboratory-grade performance on a wide range of samples, even under difficult, on-

site conditions. The instrument meets or exceeds design and performance criteria as specified in the United States Environmental Protection Agency (USEPA) Method 180.1.

By providing direct digital readout in nephelometric turbidity units (NTUs), the need for calculations or interpolation of calibration charts is completely eliminated. Hach warrants the 2100P Portable Turbidimeter against defective materials or workmanship for two years from the date of purchase.

2100P Portable Turbidimeter

FOR LABORATORY PERFORMANCE IN THE LAB AND IN THE FIELD



Specifications

Principle of Operation	Nephelometric Ratio
Operating Modes	Manual or Auto Range Selection
Measurement Mode	NTU
Range	0-1000 NTU in automatic range mode. Manual range selection of 0-9.99, 0-99.9 and 0-1000 NTU
Accuracy	± 2% of reading or ± 1 least significant digit from 0-500 NTU ± 3% of reading between 500-1000 NTU
Resolution	0.01 on lowest range
Repeatability	± 1% of reading, or 0.01 NTU, whichever is greater
Light Source	Tungsten lamp. Typical lamp life is > 100,000 readings.
Signal Averaging	Selectable on/off.
Shipping Weight	2.7 kg (6 lb)
Warranty	Two years

How to Order

46500-00

Each Model 2100P Portable Turbidimeter is supplied with nine sample cells, 100 mL each of <0.1*, 20, 100, and 800 NTU StablCal® Stabilized Formazin Standards, a set of Gelex® Secondary Standards, 15 mL silicone oil and sample cell oiling cloth, Instrument and Operations Manual, Quick Reference Card, four AA alkaline batteries and carrying case.

StablCal® Stabilized Formazin Standards

- 26594-00 Calibration Set, 500 mL each <0.1*, 20, 100, and 800 NTU
- 26595-10 Calibration Set, 100 mL each <0.1*, 20, 100, and 800 NTU
- 26594-05 Calibration Set, sealed vials <0.1*, 20, 100, and 800 NTU
- 26597-42 <0.1* NTU, 100 mL
- 26597-49 <0.1* NTU, 500 mL
- 26597-53 <0.1* NTU, 1 L
- 26601-42 20 NTU, 100 mL
- 26601-49 20 NTU, 500 mL
- 26601-53 20 NTU, 1 L
- 26602-42 100 NTU, 100 mL
- 26602-49 100 NTU, 500 mL
- 26602-53 100 NTU, 1 L

- 26605-42 800 NTU, 100 mL
- 26605-49 800 NTU, 500 mL

Optional Accessories

- 43975-00 Degassing Kit
- 43975-10 Sample Filtration and Degassing Kit
- 1269-36 Silicone Oil, 15 mL
- 47076-00 Sample Cell Oiling Cloth
- 46079-00 Battery Eliminator, 120 V
- 46080-00 Battery Eliminator, 230 V

*<0.1 NTU StablCal® Solution is used in place of low turbidity water when performing calibrations.

Other Hach Turbidimeters

Hach also offers a complete line of advanced, on-line turbidimeters for process monitoring, including the new 1720D Low Range Process Turbidimeter with the AquaTrend® Interface.

Laboratory turbidimeters include the 2100N and 2100AN Turbidimeters, which meet USEPA Method 180.1 standards, and the 2100N IS and the 2100AN IS Turbidimeters, which meet ISO 7027 standards. All four models offer wide measurement range, ease of calibration, and the application flexibility required for demanding laboratory use.

New StablCal® Stabilized Formazin Standards

Cited as a primary calibration standard in Hach Method 8195, an acceptable version of USEPA Method 180.1

Response identical to formazin primary standards, regardless of instrument

StablCal® Stabilized Formazin Standards
<1.0 NTU have a shelf life of one year from date of manufacture;
>1.0 NTU have a shelf life of two years from date of manufacture

Ultra low range standards (0.10**, 0.30 and 0.50 NTU) now available

Eliminates time-consuming dilution procedures

Simplifies turbidimeter calibrations

** 0.10 NTU StablCal® Certified Standard is a standard between 0.10 and 0.15 NTU with a defined accuracy specification that is determined for each new lot of product.



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TROLL® 9500 Multiparameter Instrument



The powerful, portable TROLL 9500 Water Quality Instrument is designed for groundwater and surface water monitoring. The unit houses up to nine water quality sensors, internal power, and optional data logger.

Lower Total Cost of Ownership

- Instrument saves time and money by offering long-lasting internal power, automated low-flow sampling, and telemetry accessibility.
- Field-proven sensors and antifouling system reduce maintenance and site visits.
- Intuitive Win-Situ® 4 Software and Flow-Sense Software improve efficiency by simplifying data collection and management.

Reliable, Accurate Operation

- Instrument operates in fresh, waste, and marine waters.
- Instrument offers proven performance. Rigorous third-party testing shows that the TROLL 9500 delivers consistent results.
- Sensors are factory calibrated with NIST®-traceable standards (where applicable).

Outstanding Customer Service

- Free, 24/7 technical support
- Seven-day service for maintenance and calibration (U.S.A. only)

Logging Models

- **LTS:** LTS stands for “Level, Temperature, and one additional Sensor,” such as conductivity, dissolved oxygen (DO), or pH.
- **Professional:** This unit offers the highest value for most applications. Instrument allows for several sensors, including conductivity/salinity, DO, ORP, pH, temperature, or depth.
- **Professional XP:** The most capable TROLL 9500 offers features available on the Professional and supports XP or “Extended Parameter” sensors—turbidity, ammonium, chloride, or nitrate.

Non-Logging Models

- **Profiler:** Ideal for sampling or vertical profiling, this unit is similar to the Professional, but does not include memory or logging capabilities. Data can be logged to a RuggedReader® Handheld PC or laptop.
- **Profiler XP:** This unit offers the same features as the Profiler with the option to use XP sensors.

Applications

- Coastal deployments—estuaries and wetlands
- Environmental monitoring and spot checking
- Low-flow groundwater sampling
- Remediation and mine water monitoring
- Stormwater management
- Vertical profiling

TROLL® 9500 Water Quality Sensors

Customizable for Your Application



Choose from several field-ready sensors. The selected sensor set will determine the diameter of the TROLL 9500—sub-2 inch or sub-4 inch.

- **Barometric pressure:** Use this sensor to compensate water level and DO values.
- **Conductivity:** Characterize water quality in actual conductivity, specific conductivity, salinity, TDS, or specific gravity.
- **DO:** Choose from the optical Rugged Dissolved Oxygen (RDO®) Sensor or Clark cell.
- **Level/Pressure:** Non-vented and vented sensors are available for several ranges.
- **Nutrients:** Choose from ion-selective electrodes for ammonium, chloride, or nitrate.
- **pH or pH/ORP:** Extend field use with durable sensors. The re-buildable pH sensor outlasts traditional sensors.
- **Temperature:** Compensate conductivity, DO, pH, and nutrient data with this fast, accurate sensor.
- **Turbidity or Turbidity/Level:** Comply with ISO standards. The turbidity sensor uses ISO 7027 method. Optional wiper is available for high-fouling sites or for lengthy deployments.



Optical RDO Sensor

Breakthrough RDO technology surpasses Clark cell performance by eliminating hydration effects, membranes, electrolyte solution, and stirring.

- **Rugged performance:** Wiper-free design excels in demanding environments. Abrasion-resistant foil withstands fouling, high sediment loads, and rapid flow rates. No photobleaching effects.
- **Automatic setup:** RDO Cap with pre-loaded calibration coefficients simplifies setup and eliminates programming errors.
- **Accurate results:** Operates with low drift over long-term deployments. Excels in hypoxic conditions. Responds quickly and maintains stable response.
- **Long-lasting calibration:** Deploys for several months if sensor fouling is minimal and if the foil is not damaged or removed.
- **Minimal interferences:** Sensor is unaffected by sulfides, sulfates, hydrogen sulfide, carbon dioxide, ammonia, pH, or chloride.
- **Fast response:** Ideal for vertical profiling and dynamically changing conditions.



TROLL 9500 Accessories



TROLL® Shield Antifouling System

The TROLL Shield Guard slows biofouling on TROLL 9500 sensors. The guard extends instrument deployments in coastal environments and at high-fouling sites by up to six weeks.

DO Field Bubbler Kit

For accurate results, use the DO Bubbler Kit for air-saturated water calibrations. The kit reduces time spent on calibration setup.

Calibration Solutions

From easy-to-use Quick Cal Solution to NIST®-traceable standards, In-Situ supplies calibration solutions required to get accurate results. Call for details or visit www.in-situ.com.

RuggedCable® Systems, Reels, & Well Accessories

RuggedCable Systems endure harsh environments and last for years. Titanium twist-lock connectors and Kellems® grip are included. Vented or non-vented cable is available in either Tefzel® or polyurethane. Order customized lengths up to 1,219 m (4,000 ft). Steel or plastic reels make deployment of long cables manageable. Ask us about well-docking accessories.



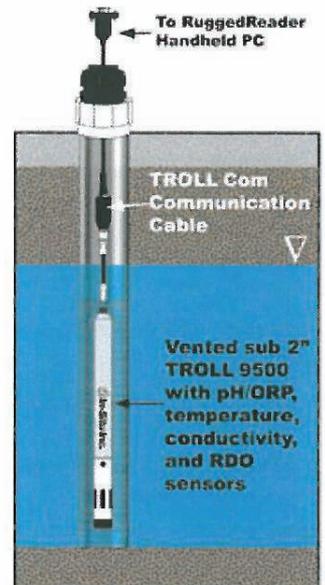
Real-Time Monitoring for Remediation



Conduct ISCO, ISCR, Biosparging, Air Sparging & More

The TROLL® 9500 Instrument supports real-time measurement of performance indicators, which allows for a dynamic work strategy per the EPA Triad Approach to site remediation. You can adapt to changing conditions as new data becomes available. This allows you to complete projects more quickly and at a lower cost than when using traditional approaches. The TROLL 9500:

- Features sub-2 inch configuration for key parameters: DO with the RDO® Sensor, conductivity, pH/ORP, temperature, and barometric pressure
- Deploys in harsh conditions. The corrosion-resistant housing is suitable for many remediation applications.
- Reduces grab sampling and labor costs while improving safety when working with treatment chemicals
- Improves performance and reduces maintenance when deployed with the RDO Sensor
- Connects to the TROLL® Link Telemetry System for remote access and external power



TROLL 9500 Low-Flow Sampling System

You can use the TROLL 9500 System with Flow-Sense Software to conduct low-flow purging and sampling. You will collect representative samples, minimize contaminant volatilization, and reduce hazardous waste disposal. To improve efficiency in the field, the system:

- Automates collection of well and pumping information
- Monitors and records stabilization of key water quality parameters
- Automatically generates defensible calibration and sample reports that conform to federal and regional regulations
- Eliminates transcription time and errors

Automated Test Setup

Flow-Sense Software retains all project information—well data, pump performance specifics, tubing details, pumping rate, stabilized drawdown, and parameter stabilization criteria. You can quickly access site information at subsequent sampling events without reentering data.

Win-Situ® Sync Software automatically copies well records and data between a computer and a RuggedReader® Handheld PC.

Automated Data Collection

Stabilization criteria are set for each monitored parameter. Data collection intervals are defined by time or pumped volumes. During sampling, software calculates and displays variance and targets for each parameter. Data is logged at pre-determined intervals and stabilization is achieved when readings meet variation criteria. In addition, you can view data numerically or graphically.



Automated Test Report Generation

After stabilization, stored data can be exported into Excel®. Flow-Sense Software automatically generates full calibration and sample reports that conform to federal and regional regulations. To save time, simply reuse templates at subsequent sampling events.

TROLL® 9500 Multiparameter Instrument

General	<i>TROLL 9500 Water Quality Instrument</i>				
Operating temp.	-5 to 50° C (23 to 122° F)				
Storage temp.	-40 to 65° C (-40 to 140° F)				
Dimensions & weight	4.7 cm (1.85 in) OD x 55.25 cm (21.75 in). With twist-lock hanger: 56.52 cm (22.25 in). Restrictor: 8.9 cm (3.5 in) OD x 21 cm (8.25 in) long; 1.9 kg (4.2 lbs)				
Wetted materials	PVC, 316L stainless steel, titanium, Acetal, Vifon®, nylon. Cable: Tefzel® or polyurethane				
Water tightness rating	IP68 with all sensors and cable attached. Battery compartment: IP67 without the battery cover or cable attached				
Output options	RS485/RS232; SDI-12 (optional with SDI-12 adapter); ASCII streaming mode or binary command				
Power	External: 9-16 VDC (optional). Internal: 2 user-replaceable D batteries (use either alkaline or matched pair of lithium). Use only Safi LSH-20 3.6V lithium D cells. Use of any other battery will void the warranty.				
Logging					
Data logging	16 programmable tests (defined, scheduled to run, or stored). Logging modes: Linear, Linear Average, Event				
Memory	4 MB (222,000 data records)				
Standard Sensors	Accuracy	Range	Depth Rating	Response Time	Methodology
Barometric pressure	±0.3% FS	16.5 psia	Meets highest rating	< 30 sec per 30 m (100 ft) of cable	Silicon strain gauge
Level, Depth, Pressure	±0.1% FS or better Sensor accuracy: -5 to 50° C	15, 30, 100, or 300 psi	<i>Non-vented</i> 30 psia: 10.90 m (35.76 ft) 100 psia: 60.11 m (197.2 ft) 300 psia: 200.7 m (658.6 ft) <i>Vented</i> 15 psig: 10.55 m (34.61 ft) 30 psig: 21.10 m (69.21 ft) 100 psig: 70.32 m (230.7 ft) 300 psig: 211.0 m (692.1 ft)	Instantaneous in thermal equilibrium	Silicon strain gauge (non-vented or vented)
Conductivity	Low: ±0.5% or 2 µS/cm High: ±0.5% + 2 µS/cm	Low: 5 to 20,000 µS/cm High: 150 to 112,000 µS/cm	Low: Meets highest rating High: Meets highest rating	Low: Instantaneous High: Instantaneous	Std. Methods 2510, EPA 120.1 Std. Methods 2510, EPA 120.1
Dissolved oxygen RDO® Sensor²	±0.1 mg/L ±0.2 mg/L ±10% of reading	0 to 8 mg/L 8 to 20 mg/L 20 to 50 mg/L	150 psi from 0 to 50° C 300 psi @ 25° C	T90: < 45 sec. T95: < 60 sec. T90: < 45 sec. T95: < 60 sec. T90: < 45 sec. T95: < 60 sec.	<i>EPA-approved In-Situ Methods⁴</i> 1002-8-2009, 1003-8-2009, 1004-8-2009
Clark cell electrode	±0.2 mg/L	0 to 20 mg/L. 0 to 200% saturation	246 m (807 ft)	1-mil membrane: 1-2 min @ 25° C 2-mil membrane: 90 sec to 3 min	Std. Methods 4500-O G, EPA 360.1
pH (single)⁵ or pH/ORP (combo)⁵	pH: ±0.1 pH unit ORP: ±5.0 mV	pH: 0 to 12 pH units ORP: ±1400 mV	pH: 211 m (692 ft) pH/ORP: 211 m (692 ft)	pH: < 15 sec. pH 7 to pH 4 ORP: < 15 sec	pH: Std. Methods 4500-H ⁺ , EPA 150.2 ORP: Std. Methods 2580
Temperature	±0.1° C	-5 to 50° C (23 to 122° F)	Meets highest rating	< 30 sec	EPA 170.1
Extended Parameter (XP) Sensors					
Ammonium (NH₄⁺)	±10%	0.14 to 14,000 ppm N	14 m (46 ft)	T98: < 60 sec, 1.4 to 14 ppm N	Std. Methods 4500-NH ₃ D, EPA 350.3
Chloride (Cl⁻)	±15%	0.35 to 35,500 ppm Cl	70 m (231 ft)	T98: < 60 sec, 3.54 to 35.45 ppm Cl	Std. Methods 4500-Cl D
Nitrate (NO₃⁻)	±10%	0.14 to 14,000 ppm N	14 m (46 ft)	T98: < 60 sec, 1.4 to 14 ppm N	Std. Methods 4500-NO ₃ D
Turbidity	±5% or 2 NTU/FNU	0 to 2,000 NTU/FNU	105 m (346 ft)	Instantaneous (5 sec for first reading)	ISO 7027
Warranty	TROLL 9500 and all sensors (excluding RDO & ISE sensors) come with a 1-year warranty. RDO Sensor: 3-year warranty. ISE sensors: 90-day warranty. RuggedCable® System: 2-year warranty.				
Notes	¹ A single data record includes time stamp, temperature, RDO, pH, and conductivity logged in Linear or Linear Average mode. ² Full operating range: 70 to 200,000 µS/cm. ³ Full operating range: 0 to 50 mg/L. ⁴ EPA-approved; call for details or visit www.in-situ.com . ⁵ pH sensor and pH/ORP sensor temperature range: 0 to 50° C.				

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